CONTRACT NO. 950137

RANGER TV SUBSYSTEM FLIGHT EVALUATION REPORT FOR FLIGHT MODEL III-4 (RA-9)

Prepared for

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

By the

ASTRO-ELECTRONICS DIVISION
DEFENSE ELECTRONIC PRODUCTS
RCA RADIO CORPORATION OF AMERICA
PRINCETON, NEW JERSEY

AED R-2692

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Preface

This report presents an evaluation of the performance of Flight Model III-4 of the Ranger TV Subsystem during the testing preceding the launch of Ranger IX and during the Ranger IX mission. This Flight Model was the last in the series of TV Subsystems designed and built by RCA for the Jet Propulsion Laboratory under Contract No. 950137, under NASA Contract NAS 7-100

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Section I
Introduction

The Ranger IX Spacecraft was launched from Cape Kenndey, Florida, at 21:37:02 GMT on March 21, 1965. At 13:49:34 GMT on March 24, 1965, video data of the lunar surface were transmitted to Earth. The picture-taking operation continued uninterrupted for 18 minutes and 46 seconds until the Ranger IX Spacecraft (RA-9) impacted on the Moon at 14:08:20 GMT. A total of 5866 pictures of the lunar surface was obtained by the full-scan and partial-scan cameras of the Flight Model III-4 TV Subsystem. The initial pictures covered regions of the central lunar highlands in the vicinity of the crater Alphonsus, and the final high resolution pictures were of the floor of the crator Alphonsus.

This report continues the documentation of the history of Flight Model III-4 TV Subsystem, which began with the "Test Report for Modified Flight Model III-4 Ranger Subsystem," issued on February 17, 1965. The period of coverage provided in this report begins with the shipment of the TV Subsystem to JPL and continues through the flight of Ranger IX. Performance of the TV Subsystem during the RA-9 mission is presented, together with a performance evaluation of the individual equipments that comprised Flight Model III-4. Preflight tests of Flight Model III-4 at JPL and at the Eastern Test Range (ETR) are described in Appendices A and B, respectively.

Flight Model III-4 was the last in the series of test and flight models of the TV Subsystem designed and built by RCA for JPL as a part of the Ranger Block III program. Flight Model III-4 was similar to the successful Ranger VIII TV Subsystem (Flight Model III-3.) Several modifications were incorporated in Flight Models III-3 and III-4 which distinguish these TV Subsystems from the Ranger VII TV Subsystem (Flight Model III-2.) These modifications are described in Section II of this report. Section III describes the Ranger IX mission and the realtime data obtained and evaluated during the mission. In Section IV, an evaluation of the individual groups of equipment that comprised the RA-9 TV Subsystem is presented. These equipments are evaluated in relation to information obtained during the mission. Section V presents the conclusions derived from the evaluation of the data obtained.

Section II

TV Subsystem Design

A. Introduction

The TV Subsystem of the Ranger IX Spacecraft basically consisted of six vidicon cameras (2 full-scan, 4 partial-scan), the electronic equipment to control these cameras, the communications chains to transmit the acquired video information back to earth, telemetry components to monitor the operation of the functional components, a completely independent power source (batteries) for the entire TV Subsystem, a structure to house and support all electronic gear, and passive thermal-control components.

The electronic equipment that comprise the functional groups of the TV Subsystem were separated into two completely redundant, electrically independent channels of operation, designated the F-Channel and P-Channel. Channel separation was characterized by the basic differences of design between the full-scan cameras and the basic differences of design between the full-scan cameras and the partial-scan cameras. The two camera types differ in the area of the scanned image, and therefore, in the scanning time and frame rate. Consequently, each channel, in addition to the cameras, consists of video-combiner, sequencer, transmitter, control, and power-distribution circuits, which enable independent or simultaneous operation of the channels.

In addition to channel separation, the components of the TV Subsystem are arranged into major functional groups. These groups are:

- Camera Group;
- Telecommunications Group;
- Controls Group;
- Power Group; and
- Thermal Design and Structure Group.

A description of each of the functional groups was presented in Section II of the "Ranger TV Subsystem Flight Evaluation Report for Flight Model III-2 (RA-7)," issued October 30, 1964.

B. RA-9 TV Subsystem Modifications

Several modifications incorporated into the Flight Model III-4 Subsystem distinguish the RA-9 TV Subsystem from the RA-7 TV Subsystem. These modifications were product-improvement, equipment-refinement, or mission-requirement type changes. The changes were based on results of the RA-7 flight, on further design studies, or were directly related to the particular constraints of the RA-9 mission. All comparisons are made to RA-7 instead of RA-8 because RA-9 was shipped to Cape Kennedy during the RA-8 mission and time did not allow for any modifications as a result of the RA-8 mission.

1. Camera Group

The modifications to the Camera Group of Flight Model III-4 TV Subsystem were:

- An improved technique, used for the first time on RA-8, was also employed on RA-9 for focusing the three TV cameras equipped with narrow-angle (76-mm) lenses (P1, P2, and F_b Cameras). This revised method provided optimum optical focus of the cameras in a true space environment by compensating, during the alignment operation, for the displacement of the plane of best focus that occurs between air and vacuum conditions as a result of the pressure dependence of the index of the index of refraction of air. In practice, a 0.0025-inch shim was used to increase the spacing between the lens and the vidicon faceplate, and the camera was subsequently optically focused in air for a maximum electrical response signal. When the shim was removed, the camera was in proper focus for operation in the space environment of an actual mission.

- The shift in optical focus because of the differences in the air and vacuum indices of refraction was computed for the TV cameras with wide-angle (25-mm) lenses (P3, P4, and F_a). The change in focus was not considered sufficient to warrant application of this technique to these three cameras.

- The gain of the F_b, P1, and P2 Cameras was increased to change the peak-scene-luminance level of these cameras from 2700 foot-lamberts to a nominal 1500 foot-lamberts as the result of actual camera performance observed during the RA-7 mission.

- New vidicon tubes with a higher-density mesh structure than previously used were installed in all cameras with the exception of the F_a Camera. The new mesh structure has 1500 instead of 750 wires per inch.

- A new type of shutter-shock isolator was fabricated in the form of a castellated pad from polyurethane Solithane 113 (Thiokol formulation 5), and Solithane material instead of Sty-cast was employed to soft mount the nuvistor in the preamplifier. These changes, along with the pre-selection of nuvistors for minimum microphonic sensitivity, were incorporated to suppress the effects of camera microphonics.

2. Telecommunications Group

The modifications to the Telecommunications Group were:

- Modification of the F- and P-Channel Transmitters and Transmitter Power Supplies to incorporate the Resdel (triode) configuration Intermediate Power Amplifiers (IPA) to provide improved temperature/frequency stability for the Transmitter chain;

- Replacement of varactor diodes in the X4 multiplier circuits of the F- and P-Channel Transmitters; (The new diodes, which have a bonded-type construction, are more reliable than the pressure-contact-type units previously employed.)

- Installation of a new-type "O" ring in the Dummy Load Assembly; (The new "O" ring results in a leak rate that is only 20 percent of the value previously encountered.)

- Relocation of the Telemetry Processor Assembly to accommodate the IPA modifications; and

- Addition of telemetry points to monitor the cathode currents of the Intermediate Power Amplifiers in the F- and P-Channel Transmitters.

3. Current Sensing Group

The circuitry of the Current Sensing Unit on Flight Model III-4 was modified to provide greater resolution of cruise-mode currents while maintaining full-power current indications within the normal telemetry range.

4. Harness Assembly

The modifications to the harness assemblies of Flight Model III-4 were:

- A new design harness was constructed, which eliminated unnecessary splices and rerouted cables;
- New High-Rel Cannon connectors were incorporated in the new harness design;
- Special molds were fabricated for forming potting material on right-angle connectors;
- Stainless-steel, screw-lock assemblies were used with the connectors;
- Novathene wire replaced the Rayolin "N" wire used in the harness of the Ranger-VII TV Subsystem; and
- Redundant battery power plugs were provided.

5. Mechanical Group

Battery-support bars fabricated from stainless steel replaced the aluminum support bars employed on Ranger VII. The use of stainless steel provides increased strength to the support bars.

6. Thermal Group

The solar absorptivity of the thermal control paints for RA-9 was reduced by using a greater percentage of white paint in the finish than was used in the RA-7 thermal finishes. This reduction in absorption was to allow for the increased solar constant existing during the anticipated March launch.

C. RA-9 Flight Assemblies

The assemblies that comprised the TV Subsystem of the Ranger IX Spacecraft are listed in Table 2-1. This table includes reference designation, serial number, and prelaunch operating time of each assembly. Prelaunch operating times for both channels are given in Table 2-2.

TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-4 TV SUBSYSTEM

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
P1 Camera	A1A1	015	175.8
Lens		1890	
Vidicon		J3301	
Shutter		3051R1	44.7
P2 Camera	A1A2	039	117.5
Lens		749-1	
Vidicon		J3315	
Shutter		3038R2	27.9
P3 Camera	A1A3	043	102.9
Lens		779	
Vidicon		J3313	
Shutter		3009R1	46.0
P4 Camera	A1A4	049	156.9
Lens		861	
Vidicon		J3333	
Shutter		3069	34.2
F_a Camera	A1A5	044	114.3
Lens		808	
Vidicon		813	
Shutter		026R2	20.3
F_b Camera	A1A6	014	276.3
Lens		1889	
Vidicon		J1226	
Shutter		023R1	67.5

TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-4 TV SUBSYSTEM (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
P1 Camera Electronics	A2	015	175.8
P2 Camera Electronics	A3	033	117.5
P3 Camera Electronics	A4	043	102.9
P4 Camera Electronics	A5	049	156.9
F_a Camera Electronics	A6	044	114.3
F_b Camera Electronics	A7	014	276.3
Video Combiner	A8	009	68.3
Sequencer	A9	0005	74.7
F Battery	A10	109	
P Battery	A11	107	
F-Channel HCVR	A12	11	73.6
F-Channel Transmitter	A14	211	138.6
F-Channel Power Amplifier/ Pres. Vessel	A15	158/301	104.5
F Transmitter Power Supply	A16	012	119.4
Low Current Voltage Regulator	A17	9	495.3
P-Channel Transmitter	A19	204	171.2
P-Channel Power Amplifier/ Pres. Vessel	A20	145/016	135.7
P Transmitter Power Supply	A21	20	135.7
Four-Port Hybrid	A24	003	146.0
Dummy Load/Pres. Vessel	A25	027/005	153.2
Telemetry Assembly	A26	107	
15-Point Commutator	A26A1	5911	493.7
90-Point Commutator	A26A2	5913	93.9
Power Supply	A26A3	11	

TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-4 TV SUBSYSTEM (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
3-KC Voltage Controlled Oscillator (VCO)	A26A4	3433	
AC Amplifier	A26A5	011	
225-KC VCO (P-Channel)	A26A6	009	
225-KC VCO (F-Channel)	A26A7	002	
Temperature Sensor	A27	9	494.4
Sequencer Power Supply	A28	0005	75.6
F-Channel Telemetry Processor	A29	021	120.1
P-Channel Telemetry Processor	A30	006	116.9
Distribution Control Unit	A34	005	107.6
Electronic Clock/Plug	A35	007/002	
P-Channel HCVR	A37	15	104.7
Filter Assembly	A38	5	85.6
Command Control Unit	A39	007	190.6
Current Sensing Unit	A40	006	649.5
Current Transformer Unit	A41	023	572.4
Current Transformer Unit	A42	022	572.4
F-Battery Jumper Plug	30P13	003	
P-Battery Jumper Plug	30P14	003	
Harness Assembly	30W1	003	
Harness Assembly	30W2	002	
Harness Assembly	30W3	003	
Harness Assembly	30W4	003	
Harness Assembly	30W5	002	

TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-4 TV SUBSYSTEM (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
Harness Assembly	30W6	003	
Harness Assembly	30W7	002	
Harness Assembly	30W8	003	
Harness Assembly	30W9	003	
Harness Assembly	30W10	002	
Harness Assembly	30W11	003	
Harness Assembly	30W12	002	
Cable Assembly	30W14	003	
Cable Assembly	30W15	005	
Cable Assembly	30W24	003	
Harness Assembly	30W25	003	
Harness Assembly, RF	30W26	013	
Harness Assembly, RF	30W27	013	
Harness Assembly, RF	30W28	011	
Harness Assembly, RF	30W29	008	
Harness Assembly	30W30	003	
Harness Assembly	30W31	003	
Cable Assembly, RF	30W32	013	
Cable Assembly, RF	30W33	003	
Harness Assembly	30W36	003	
Harness Assembly	30W38	003	
Harness Assembly	30W39	003	
Harness Assembly	30W40	003	

TABLE 2-2
FLIGHT MODEL III-4 OPERATING TIMES PRIOR TO LAUNCH

Channel	Condition	Operating Time
F-Channel	Warm Up	17 hrs 39 min.
	Full Power	69 hrs 55 min.
	Reduced Power	0 hrs 59 min.
P-Channel	Warm Up	30 hrs 45 min.
	Full Power	79 hrs 42 min.
	Reduced Power	0 hrs 59 min.

Section III

Ranger IX Mission and Real-Time Data

A. Spacecraft Data Analysis Team

1. General

The TV Subsystem group within the Spacecraft Data Analysis Team (SDAT) established the pre-flight procedures and guidelines for control of the RA-9 TV Subsystem both for standard and nonstandard modes of operation during the RA-9 mission and analyzed the TV Subsystem telemetry data being transmitted by the Spacecraft in order to determine the best possible flight plan of the Spacecraft for optimun performance of the TV Subsystem.

The deep-space tracking network, with stations at Woomera, Australia; Johannesburg, Republic of South Africa; and Goldstone, California, received the transmitted telemetry signals from the Spacecraft and relayed the data, in near real time, to the Flight Operations Facility at the Jet Propulsion Laboratory in Pasadena, California. The TV Subsystem analysis group analyzed this data, determined the condition of the TV Subsystem, and established the flight procedure for the remainder of the mission. It was the responsibility of the TV Subsystem group to inform the SDAT and Flight Operations Director (FOD) of any changes to the flight plan required to obtain optimum TV Subsystem performance. This group also assisted in the prelaunch test evaluation as telemetry data was transmitted, in real time, from the Eastern Test Range (ETR). Thus, from launch minus approximately 3 hours to impact, the analysis group for the TV Subsystem continuously monitored and analyzed the data from the TV Subsystem. The Tracking and telemetry equipment at Cape Kennedy, Goldstone, Woomera, and Johannesburg Deep Space Instrumentation Facilities (DSIF) provided continuous telemetry coverage except for 15 minutes (day 80 - 21:44:43 to 21:59:33 GMT) during the transfer from Cape Kennedy (DSIF-71) to Johannesburg (DSIF-51). Based on these data, the analysis group continuously updated the TV Subsystem flight procedure to ensure that the RA-9 mission requirement would be fulfilled; that is, high resolution television pictures of the lunar surface would be obtained.

2. Ranger IX Mission Profile

a. Prelaunch

Approximately 3 hours before launch, the TV Subsystem was turned on in the reduced power mode for a final system check. Telemetry and video indications were normal except for one telemetry temperature sensor, which was recalibrated at this time. The countdown continued; at launch minus 25 minutes, cruise-mode telemetry was turned on. The telemetry data, evaluated by both the ETR launch team and the TV Subsystem analysis group, indicated that all assemblies of the TV Subsystem were functioning normally.

b. Launch

The Ranger IX Spacecraft was successfully launched from the ETR at 21:37:02 GMT on February 21, 1965. The launch was accomplished by an Atlas-Agena launch vehicle. The complete RA-9 mission events list is presented in Table 3-1. At launch, the umbilical cable was disconnected from the launch vehicle, removing the full-power-inhibit circuit, which permitted only a reduced-power Subsystem output of approximately 125 milliwatts. The TV Subsystem telemetry data received by the analysis group from the ETR during launch confirmed that the TV Subsystem parameters were normal during the entire launch phase. The tracking station at Johannesburg acquired the Spacecraft approximately 22 minutes after launch and started sending telemetry data to SDAT. The Spacecraft entered the Earth's shadow at approximately the time of Johannesburg acquisition and remained in the shadow for 33 minutes. The temperature sensors located on the external shrouds of the TV Subsystem indicated the resulting decrease in temperature during this time.

c. Cruise Mode

Agena-booster separation occurred at launch (L) +15.4 minutes and generated a command to the TV Subsystem Clock to start its 63.5-hour count. Clock turn-on was verified on cruise-mode telemetry. Agena-booster separation also provided a backup for the removal of the full-power-inhibit circuit, and started a mechanical timer that provided backup functions for the Spacecraft. One of these functions was to enable the silicon controlled rectifiers (SCR) gates in the TV Subsystem High-Current Voltage Regulators at separation plus 30 minutes. Approximately 15 minutes after separation, the Spacecraft solar panels were deployed and activated a microswitch which provided a backup circuit to enable the SCR gates. At L+70 minutes,

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TABLE 3-1
RA-9 MISSION EVENTS LIST

Mission Event	Event Time (GMT)		Nominal
	Predicted	Actual	Mission Time
Day 80			
Prelaunch Test On		17:56:00	T-221 min
Prelaunch Test Off		18:01:01	-
Cruise-Mode Telemetry On	-	20:41:31	T-55.5 min
Spacecraft on Internal Power	21:32:00	21:32:03	T-5 min
CC&S Uninhibit	21:35:00	21:35:00	T-2 min
CC&S Clear	21:36:00	21:36:00	T-1 min
Launch (L)	21:37:01	21:37:02	T = L = 0
Enter Earth's Shadow	-	21:50:22	-
Spacecraft/Agena Separation (S)	21:52:30	21:52:26	-
TV Clock Start	21:52:30	21:52:26	S = 0
DSIF-51 View Period Start	-	21:59:33	-
Transmitter Power Up	22:00:00	-	L+23
Leave Earth's Shadow	-	22:24:01	-
Solar Panels Extend Command	22:37:00	22:37:01	L+60 min
Solar Panels Extended	22:37:47	22:37:51	-
Sun Acquisition Command	22:40:00	22:40:01	L+63 min
Sun Acquisition Complete	-	22:47:30	-
DSIF-41 View Period Start	-	22:56:45	-
Day 81			
DSIF-41 View Period End	-	00:57-56	-
Earth Acquisition Command	01:08:00	01:08:02	L+211 min
Earth Acquisition Complete	-	01:11:50	-
TV Clock 8-Hour Pulse	05:52:33	05:52:36	S+8 hours
DSIF-12 View Period Start	-	08:28:39	-
DSIF-51 View Period End	-	09:41:49	-
DSIF-41 View Period Start	-	13:34:48	-
TV Clock 16-Hour Pulse	13:52:39	13:52!47	S+16 hours
DSIF-12 View Period End	-	17:35:44	-
DSIF-51 View Period Start	-	21:02:44	-
TV Clock 24-Hour Pulse	21:52:55	21:52:54	S+24 hours

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TABLE 3-1
RA-9 MISSION EVENTS LIST (Continued)

Mission Event	Event Time (GMT)		Nominal
	Predicted	Actual	Mission Time
Day 82			
DSIF-41 View Period End	-	02:59:55	-
TV Clock 32-Hour Pulse	05:53:01	05:53:01	S+32 hours
DSIF-12 View Period Start	-	08:51:09	-
DSIF-51 View Period End	-	10:22:48	-
Midcourse Maneuver Start (M)	12:03:39	12:03:40	M = 0
Roll Correction Start	12:03:44	12:03:46	M+5 sec
Roll Correction End	12:05:52	12:05:52	-
Pitch Correction Start	12:13:10	12:13:09	M+9.5 min
Pitch Correction End	12:22:57	12:22:57	-
Midcourse Motor Ignition	12:30:10	12:30:09	M+26.5 min
Midcourse Motor Turn-off	12:30:40	12:30:40	-
Sun Reacquisition Command	12:33:40	12:33:40	M+30 min
Sun Reacquisition Complete	12:42:40	12:42:20	-
Earth Reacquisition Command	13:01:40	13:01:40	M+58 min
Earth Reacquisition Complete	13:41:40	13:02:40	-
DSIF-41 View Period Start	-	13:57:45	-
DSIF-12 View Period End	-	18:06:10	-
DSIF-51 View Period Start	-	21:17:41	-
TV Clock 24-Hour Pulse	21:53:15	21:53:28	S+24 hours
Day 83			
DSIF-41 View Period End	-	3:14:40	-
DSIF-12 View Period Start	-	8:55:27	-
DSIF-51 View Period End	-	10:33:01	-
RTC-6 Command Sent	-	13:02:34	T-40 sec
Terminal Maneuver Start (T)	13:03:13	13:03:15	T = 0
Pitch Correction No. 1 Start	13:03:20	13:03:20	T+5 sec
Pitch Correction No. 1 Complete	13:03:44	13:03:44	-
Yaw Correction Start	13:12:44	13:12:44	T+9.5 min
Yaw Correction Complete	13:13:59	13:13:59	-
RTC-5 Command Start	13:17:00	13:17:00	-
TV Clock Off	-	13:17:38	-
Pitch Correction No. 2 Start	13:29:44	13:29:44	T+26.5 min
Pitch Correction No. 2 Complete	13:31:18	13:31:17	-

TABLE 3-1
RA-9 MISSION EVENTS LIST (Continued)

Mission Event	Event Time (GMT) Predicted	Event Time (GMT) Actual	Nominal Mission Time
Day 83 (Cont'd)			
CC&S TV Turn-on (Warmup)	13:48:14	13:48:13	T+45 min
TV Full-Power On	13:49:34	13:49:34	-
RTC-7 Command (Not Used)	13:53:14	-	T+50 min
DSIF-41 View Period Start	-	14:03:01	-
Impact	14:08:20	14:08:20*	I

* This time is actual impact time (1.3 seconds transmitting time was subtracted from end of data time).

Spacecraft acquisition of the sun was accomplished, and 2 hours and 24 minutes later, Earth acquisition occurred. Thus, the Spacecraft was oriented in its normal cruise-mode position, with the Z-axis pointing toward the sun and high-gain antenna pointing toward the Earth. The 15-point telemetry continued to indicate normal performance with the 8- and 16-hour Clock telemetry steps occurring at the predicted times. Mid-course maneuver was initiated at approximately L + 40 hours. The 15-point telemetry data from the TV Subsystem were interrupted for 10 minutes and 43 seconds during midcourse maneuver so that propulsion and attitude-control information could be transmitted over Channel 8. The midcourse maneuver consisted of a roll turn of -27.4° and then a pitch turn of +127.9°. Thus, the -Y shroud and top-hat surfaces were oriented toward the sun and rose to a peak temperature of 98°F and 124°F respectively during the pitch turn. At the end of midcourse maneuver, the Spacecraft was reoriented in its normal cruise-mode position, and 1 hour later, the temperatures of the TV Subsystem had returned to the pre-midcourse values.

The 24- and 32-hour Clock telemetry steps occurred on time. At the time of the 32-hour step, the Clock also provided an output signal, which removed the Clock-output inhibit and the RTC-5 Clock turn-off inhibit. Forty-five hours after launch, the TV Subsystem temperatures stabilized at the following values:

- F_a Camera Lens Housing 65°F

- P-Channel Battery 78°F
- Top Hat (shroud) 79°F
- Lower Shroud 77°F
- F_b Camera Electronics 70°F

The 48-hour Clock telemetry signal occurred 62 (+0, -15) seconds late. This indicated that the Clock was running slow but well within the 5-minute overall tolerance.

d. Terminal Mode

The following information was used to determine the sequence of terminal events:

- The Experimenters reported that pictures taken before approximately 18 minutes to impact would be no better than earth-based photographs.
- The Spacecraft was functioning normally and could be expected to perform a normal terminal maneuver.
- The TV Subsystem was functioning normally. Analysis of the battery capacities and Subsystem temperatures indicated that the F and P Channels could operate in the full power mode for 60 and 30 minutes, respectively. However, it was noted that for these times, the final transmitter temperatures would be 5 to 10 degrees F higher than any temperatures seen during RA-9 testing but not higher than temperatures on the PTM and QTM units during testing.

Based on the above, it was decided that the clock would be turned off after proper operation of the CC&S had been verified during Spacecraft terminal maneuver, so that the CC&S could be relied on to turn on the TV Subsystem. If there were any doubt about the command link or the operation of the CC&S unit, the RTC-5 command was not to be sent. In order to send the RTC-5 command between the end of the yaw turn and the predicted Clock turn-on, the terminal maneuver was started at I-65 minutes instead of I-60 minutes.

The RTC-6 command was sent at 13:02:34 to start the Spacecraft CC&S counter which supplies the terminal-maneuver commands to the attitude control system and the warmup (turn-on) and backup full-power commands to the TV Subsystem. The RTC-5 command was sent at 13:17:00 to turn off the TV Subsystem Clock. Upon receipt of the RTC-5 command by the Spacecraft, the Clock and F-Channel Battery current telemetry readings went to 0 and the F-Channel Battery voltage increased approximately 0.5 volt indicating that the Clock had been turned off. At the predicted time, of 13:48:13, the Spacecraft CC&S commanded the F and P Channels into warmup mode, and 80 seconds later, each channel was switched into full power by the associated Camera Sequencer. For the next 19 minutes, both channels transmitted video pictures of the lunar surface.

3. RA-9 TV Subsystem Telemetry

a. General

TV Subsystem telemetry information was obtained to monitor the important Subsystem parameters so that any necessary, real-time adjustments could be made to correct or improve Subsystem performance. In the event of a failure, an analysis would be made of the telemetry data to isolate the cause of the failure. A PAM/FM/FM* telemetry system was employed to monitor 104 parameters of the TV Subsystem. The 90-point telemetry data were transmitted by the P-Channel high-power transmitters on the TV Subsystem as a 225-kc subcarrier on the main signal, and by the Spacecraft's low-power Transmitter on an IRIG** Channel-8 3-kc subcarrier. Channel 8 was the prime data link. During cruise mode, a 15-point commutator sampled eleven Subsystem data points and four telemetry references in the TV Subsystem. When either the F or P Channel of the TV Subsystem is placed into the warmup mode, the cruise-mode telemetry data is switched from Channel 8 to the TV Subsystem F-Channel Transmitter and the diagnostic telemetry sampled by a 90-point commutator is transmitted over Channel 8. The format for the 90-point commutator is the same as that for the 15-point commutator shown in Figure 3-1, except that more and different data points are sampled. The data points are listed in Table 3-2.

b. Flight Operations Facility

In the Data Analysis area of the Spacecraft Flight Operations Facility (SFOF), several devices were employed for monitoring Subsystem telemetry data. The 3-kc analog telemetry signal was received during Spacecraft contacts by the Goldstone and Woomera tracking stations, and was sent directly to the SFOF for display on a

* PAM/FM/FM-pulse amplitude modulated/frequency modulated/frequency modulated
** IRIG - Intra Range Instrumentation Group

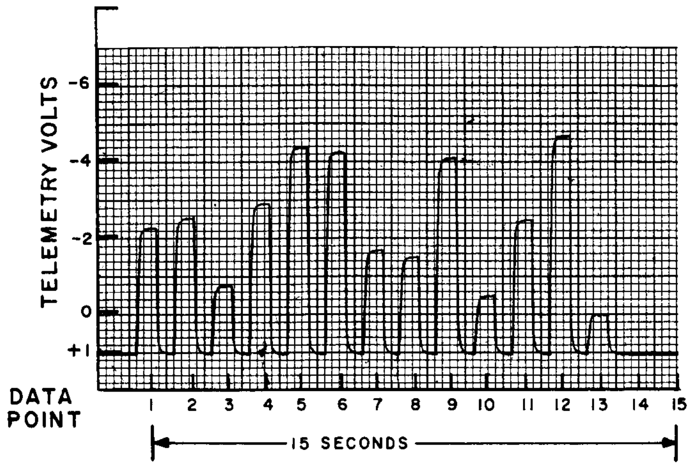
Sanborn strip-chart recorder. This telemetry signal was also fed into a Central Computing Complex (CCC), which sampled each data point and printed out the actual engineering units or telemetry voltage for that point. The CCC has four modes of operation: three in cruise mode and one in terminal mode. The CCC printer output for Mode 1 is in raw data units; for Mode 2, the output is in telemetry units; for Mode 3, engineering units. The CCC Mode 4 provides a printer output of 13 selected data points of the 90-point terminal telemetry in telemetry units. The CCC was limited to single-mode operation in real time. The telemetry data were also displayed on strip-chart recorders at all tracking stations. The telemetry information was read off the strip charts at 30-minute intervals and the value sent to the SDAT via the administrative teletype network. During Spacecraft passes over the Johannesburg station, the administrative teletype messages were the only source of data available as the analog telemetry signal was not available to the SFOF from this station.

The telemetry points of the TV Subsystem were calibrated prior to flight in accordance with the procedures of RCA Specification RTSP 1100A, Appendix N. Several of the data points in the camera equipment monitor two parameters and are not easily calibrated when installed in the Subsystem. Thus, the camera telemetry points are calibrated during bench test and verified during the systems tests performed before flight. The calibration data were fed into a computer which produced tables that converted telemetry voltages into the associated engineering units. These tables were used for conversion of the telemetry data during the flight. At various times during cruise mode, depending on when computer time was available, a tape recording of the received cruise-mode telemetry data was fed into the computer programmed to plot the data as a function of time and also to print out a complete listing of the data in engineering units as a function of time.

At approximately 1 minute before TV Subsystem turn-on in terminal mode, the computer was programmed for the 90-point diagnostic telemetry data. The data outputs available to the Subsystem analysis group during terminal mode were:

- Strip-chart recording of the analog telemetry signal in real time;
- Real-time computer printouts of selected telemetry points;
- Matrix printouts of all 90-point telemetry data about 1.5 to 2 minutes behind real time;
- Telephone and administrative teletype messages of selected telemetry points as read on the strip-chart recorders from the Goldstone Tracking Station.

After impact, the computer tabulations and plots of the 90-point telemetry data were available.



Data Point No. and Parameter Monitored	Telemetry Volts(-)	Engineering Units
1. F_a Camera Lens Housing Temperature	2.26	62.3°F
2. LCVR Output Voltage	2.53	27.4 volts
3. P-Battery Current	0.78	0.146 ma
4. P-Battery Internal Temperature	2.90	76.3°F
5. F-Battery Terminal Voltage	4.36	34.7 volts
6. P-Battery Terminal Voltage	4.26	34.7 volts
7. Top Hat Temperature (-y side)	1.68	79.2°F
8. Lower Shroud Temperature (-y side)	1.50	73.7°F
9. Clock Time Steps	4.08	32 to 48 hr period
10. F-Battery Current	0.48	0.034 ma
11. F_b-Camera Electronics Temperature	2.48	68.8°F
12. Full Scale Reference	4.7	-
13. Zero Reference	0.0	-
14. Frame Reference	+1.07	-
15. Frame Reference	+1.07	-

Figure 3-1. Sample frame of cruise-mode telemetry data from 15-point commutator (Goldstone Tracking Station)

TABLE 3-2
TV SUBSYSTEM DATA POINTS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR

Data Point No.	Parameter Monitored
1	P1 Camera Vertical Sweep
2	P1 Camera Horizontal Sweep
3	P1 Camera G1 and Focus Current
4	P1 Camera +1000 V and 300 V
5	P1 Camera Shutter and Lamp Drive
6	P1 Camera Vidicon Filament
7	Zero Reference
8 thru 14	Same as 1 thru 7 except for P2 Camera
15 thru 21	Same as 1 thru 7 except for P3 Camera
22 thru 28	Same as 1 thru 7 except for P4 Camera
29 thru 34	Same as 1 thru 6 except for F_a Camera
35	Full-Scale Reference
36 thru 42	Same as 1 thru 7 except for F_b Camera
43	F_b Camera Electronics Temperature (Sensor No. 2)
44	F Battery Case Temperature (Sensor No. 4)
45	P Battery Case Temperature (Sensor No. 5)
46	P Unregulated Bus
47	P Regulated Bus (-27.5 V)
48	F Unregulated Bus
49	F Regulated Bus (-27.5 V)
50	Lower Shroud Temperature (+Y) (Sensor No. 12)
51	Bottom Deck Temperature (-X, -Y Quadrant) (Sensor No. 13)
52	Second Deck Temperature (-Y) (Sensor No. 14)
53	Second Deck Temperature (+Y) (Sensor No. 15)
54	LCVR Input Voltage
55	F-Channel full-power Command

TABLE 3-2
TV SUBSYSTEM DATA POINTS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR (Continued)

Data Point No.	Parameter Monitored
56	P-Battery Current
57	F-Battery Current
58	F-Battery Terminal Voltage
59	P-Battery Terminal Voltage
60	P-Channel Full-Power Command
61	F Sequencer "T" Flip-Flop (No. 2)
62	Zero Reference
63	F Sequencer Oscillator (18Kc)
64	P Sequencer Voltage (+12V)
65	P Sequencer Voltage (-12V)
66	P Sequencer Oscillator (18 Kc)
67	F Sequencer Voltage (+12V)
68	F Sequencer Voltage (-12V)
69	F Sequencer "T" Flip-Flop (No. 1)
70	P Sequencer "R" Flip-Flop (No. 1)
71	P Sequencer "R" Flip-Flop (No. 2)
72	P Video Combiner Output
73	F Transmitter IPA Cathode Current
74	F Video Combiner Output
75	P-Transmitter PA Heat Sink (Sensor No. 6)
76	F-Battery Internal Temperature (Sensor No. 8)
77	F Transmitter PA (+1000 V)
78	F Transmitter IPA (-500 V)
79	F Transmitter PA Cathode Current
80	F Transmitter PA Heat Sink (Sensor No. 7)

TABLE 3-2
TV SUBSYSTEM DATA POINTS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR (Continued)

Data Point No.	Parameter Monitored
81	P Transmitter IPA Cathode Current
82	P Transmitter PA (+1000 V)
83	P Transmitter IPA (-500 V)
84	P Transmitter PA Cathode Current
85	F_a Camera Lens Housing Temperature (Sensor No. 1)
86	Camera Bracket Temperature (Sensor No. 3)
87	Full Scale Reference
88	Zero Reference
89	Frame Reference
90	Frame Reference

4. SDAT Data Accuracy

To establish the accuracy of the telemetry data from the various stations, cruise-mode telemetry data from Woomera, Goldstone, and Johannesburg tracking stations were plotted as minimum and maximum values sampled every hour. The telemetry points plotted were the Clock pulse (15-9), the LCVR (15-2), and the lower-shroud temperature (15-8). All stations varied no more than 0.1 volt from the nominal value. A comparison of the backup Clock telemetry readings between S + 32 and S + 48 hours is given in Table 3-3.

5. Comparison of 15-point and 90-point Telemetry

When the TV Subsystem was placed into warmup, the 90-point telemetry data were transmitted over the Spacecraft Channel 8. Since these 90 points include values for some of the same data points as sampled by the 15-point telemetry during cruise mode, a basis of comparison was provided for ensuring the accuracy of the telemetry analysis. A strip-chart recording of analog telemetry transmitted over F Channel and Channel 8 was made at the Goldstone Tracking Station on day 83, starting at 13:56:56 (approximately 10 minutes before impact) and just prior to impact. It was examined for changes in telemetry units. The results of this comparison are presented in Table 3-4 and are well within expected limits.

TABLE 3-3
COMPARISON OF TELEMETRY READINGS FOR THE ELECTRONIC CLOCK

Station	High	Low	Average
Woomera (DSIF-41)	4.1	4.0	4.09
Goldstone (DSIF-12)	4.1	4.05	4.09
Johannesburg (DSIF-51)	4.2	4.0	4.11
CCC-6 (Computer)	4.3	4.0	4.12

6. Telemetry Evaluation of TV Subsystem Performance

The cruise-mode telemetry was employed to monitor TV Subsystem temperatures and power-supply operation. The actual temperatures of the TV Subsystem assemblies during cruise and terminal modes were almost exactly as predicted in preflight calculations. The cruise-mode temperatures are plotted in Figures 3-2 through 3-6. Terminal mode temperatures are plotted in Figures 3-7 through 3-22.

During Spacecraft reduced-power tests at Cape Kennedy, the P-Battery case temperature sensor (90-point telemetry, data point No. 45) was not in the proper resistance range. However, since this point is almost redundant with data point No. 4 of the 15-point telemetry, P-Battery internal temperature sensor, it was decided to recalibrate rather than change this part. It was concluded that the higher resistance on data point No. 45 might be due to a crack in the sensor. Therefore, there was a possibility that the launch environment would further change the sensor characteristics and render it useless as a telemetry measure. During the actual Ranger IX mission this sensor gave erroneous readings as compared to the readings on the 15-point telemetry.

The TV Subsystem power supply consisted of a Battery and a High Current Voltage Regulator (HCVR) for each of the F and P Channels, and a Low Current Voltage Regulator (LCVR) on the P Channel only. The power-supply units functioned nominally throughout the mission. An evaluation of the power-supply units, based on analysis of the telemetry obtained, is presented in Section IV, Paragraph F.

TABLE 3–4
COMPARISON OF 15-POINT AND 90-POINT TELEMETRY READOUTS DURING TERMINAL MODE

	Frame Started at 13:56:56 GMT			Frame Started at 14:07:00 GMT			Last Frame Started at 14:07:32 GMT		
Telemetry Channel / Parameter Monitored	15 pt F Ch	90 pt Ch 8	90 pt P Ch	15 pt F Ch	90 pt Ch 8	90 pt P Ch	15 pt F Ch	90 pt Ch 8	90 pt P Ch
F_a Camera Lens Housing	2.5	2.5	-	2.6	2.55	2.55	2.6	2.6	2.55
P-Battery Current	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.3	4.4
F-Battery Terminal Volts	3.6	3.6	3.6	3.6	3.6	3.7	3.6	3.6	3.62
P-Battery Terminal Volts	3.45	3.5	3.45	3.5	3.45	3.5	3.5	3.5	3.45
F-Battery Current	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.35
F_b Camera Electronics	2.6	2.6	2.6	2.8	2.75	2.75	2.8	2.75	2.75
F Transmitter IPA Cathode Current	-	1.5	1.5	-	1.4	1.5	-	1.5	1.5
F Transmitter PA Cathode Current	-	1.3	1.3	-	1.3	1.35	-	1.3	1.3
P Transmitter IPA Cathode Current	-	1.5	1.5	-	1.35	1.4	-	1.35	1.35
P Transmitter PA Cathode Current	-	2.3	2.2	-	2.25	2.3	-	2.3	2.25
P Transmitter PA Heat Sink	-	1.7	1.7	-	2.1	2.2	-	2.15	2.2
F Transmitter PA Heat Sink	-	1.9	1.9	-	2.5	2.5	-	2.45	2.5

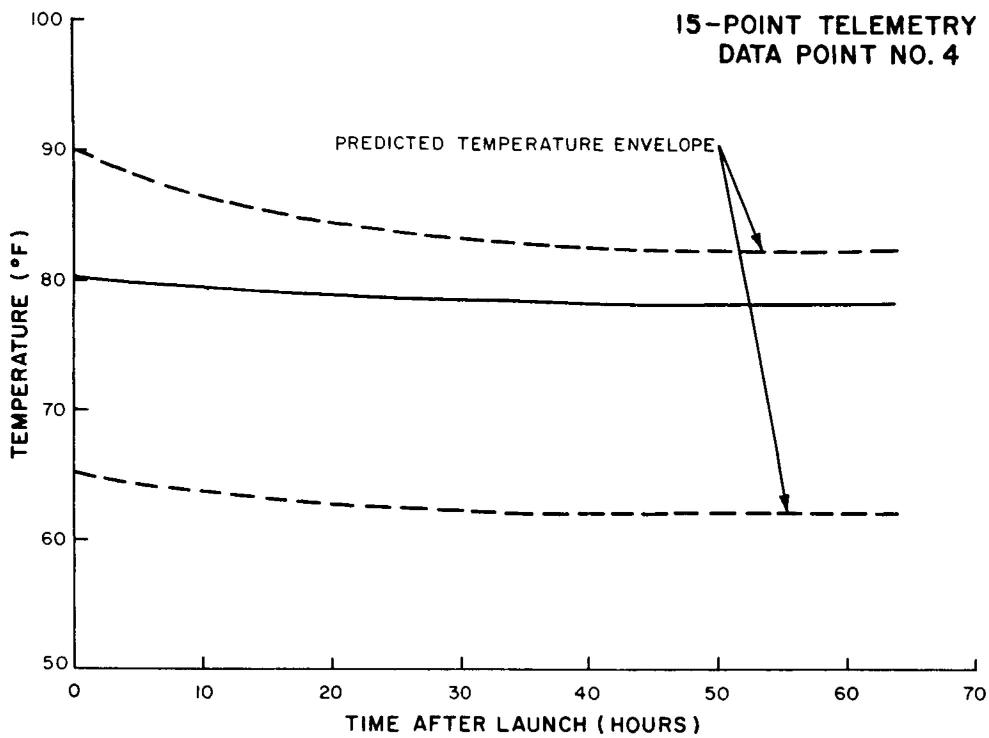


Figure 3-2. Actual F_a Camera Lens Housing temperature during cruise mode

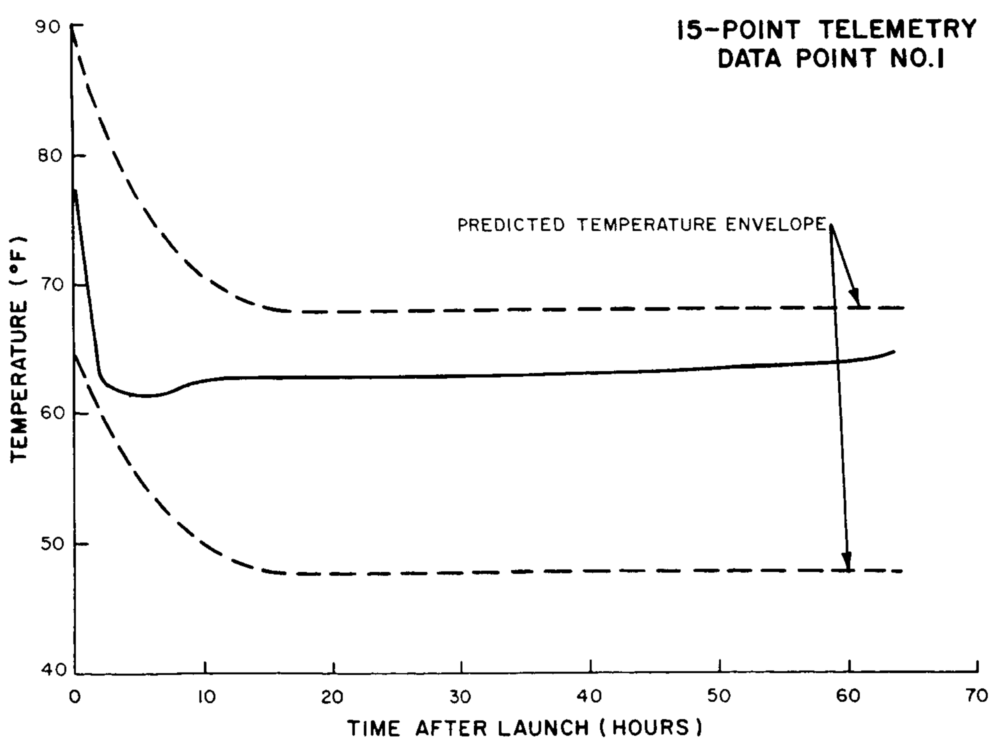


Figure 3-3. Actual P-Battery Internal temperature during cruise mode

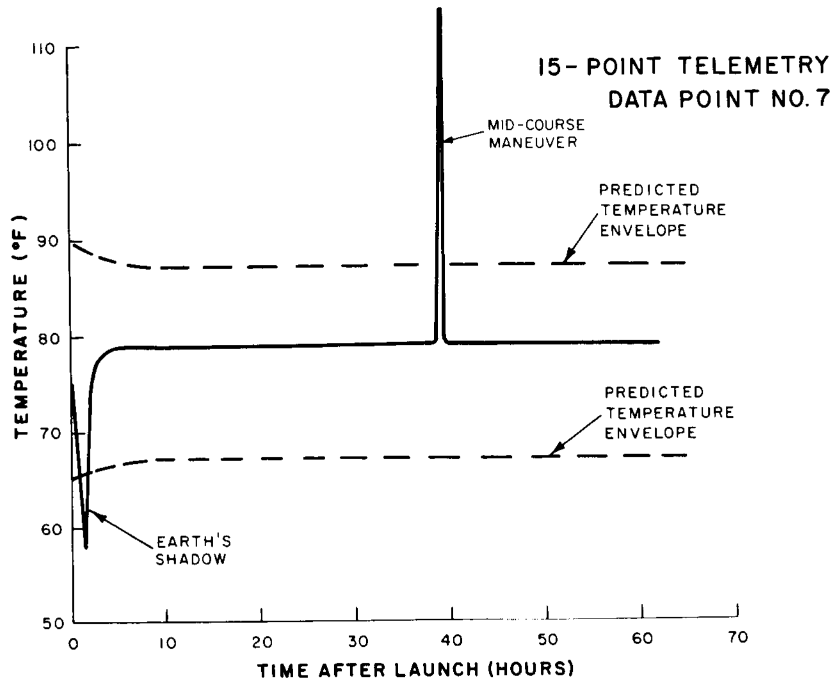


Figure 3-4. Actual Top Hat temperature during cruise mode

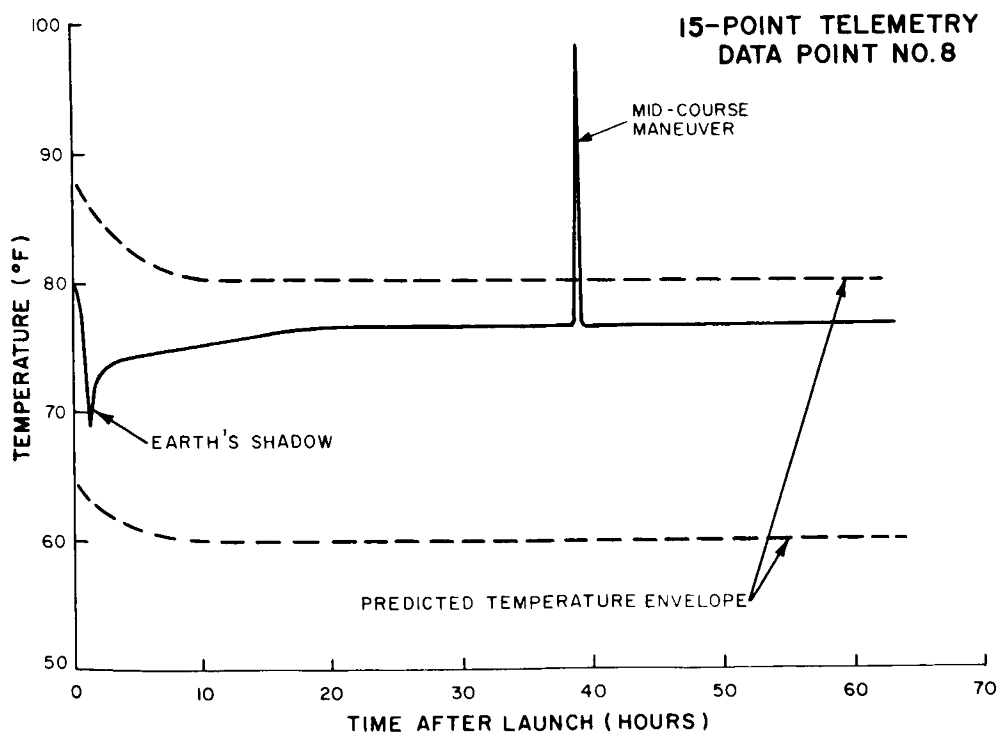


Figure 3-5. Actual Lower Shroud temperature during cruise mode

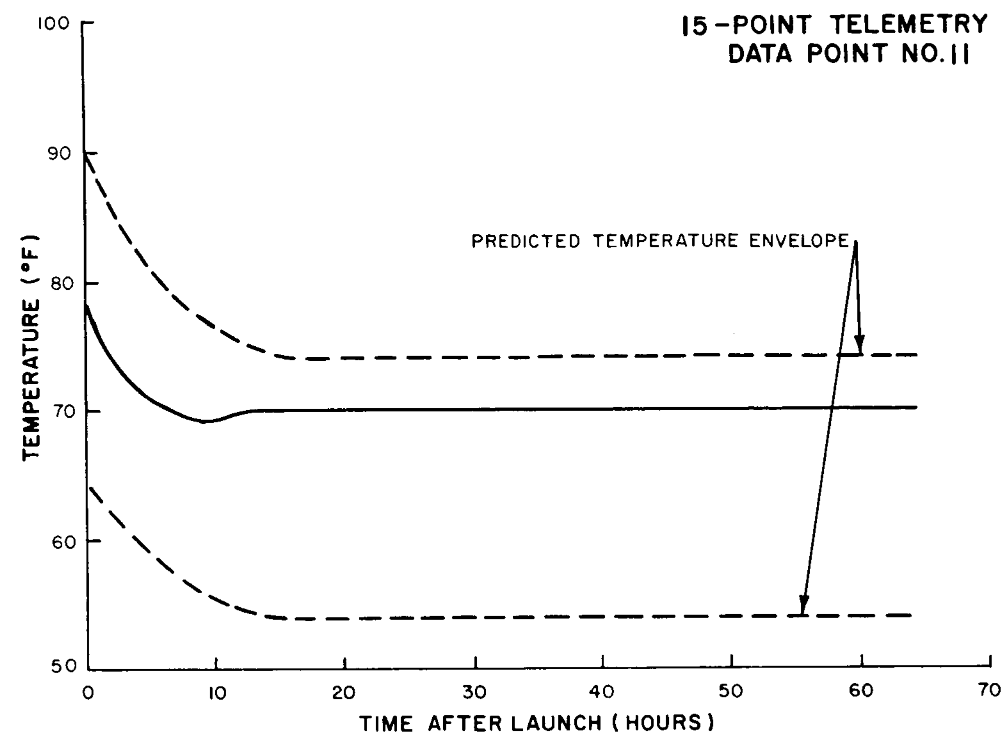


Figure 3-6. Actual F_b Camera Electronics temperature during cruise mode

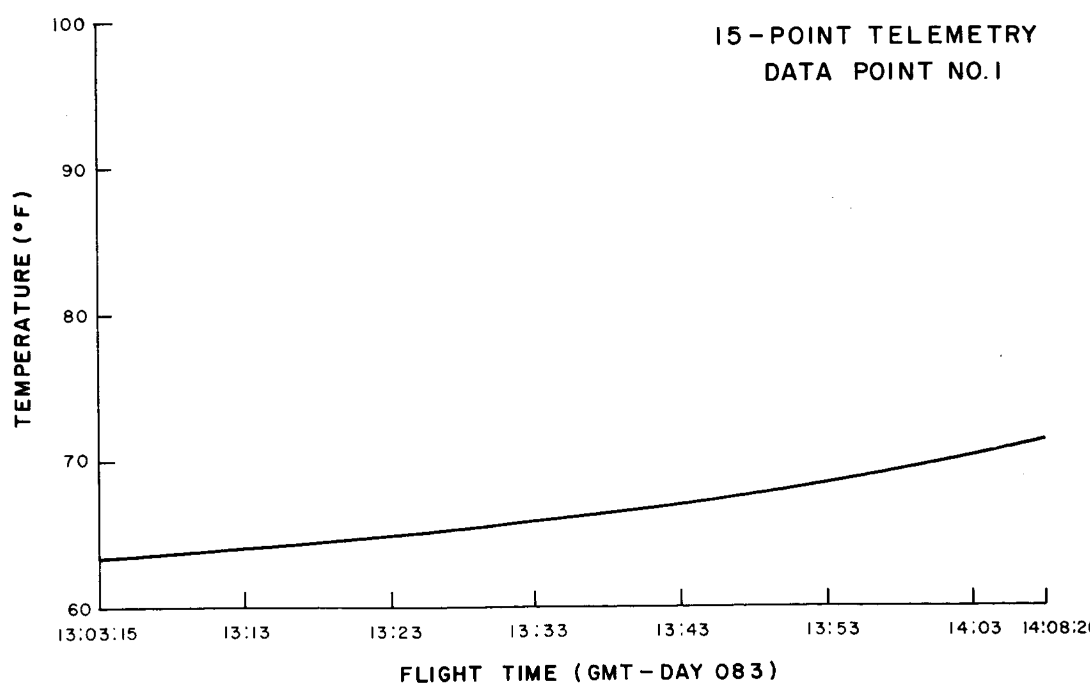


Figure 3-7. Actual F_a Camera Lens Housing temperature during terminal mode as monitored by the 15-point telemetry

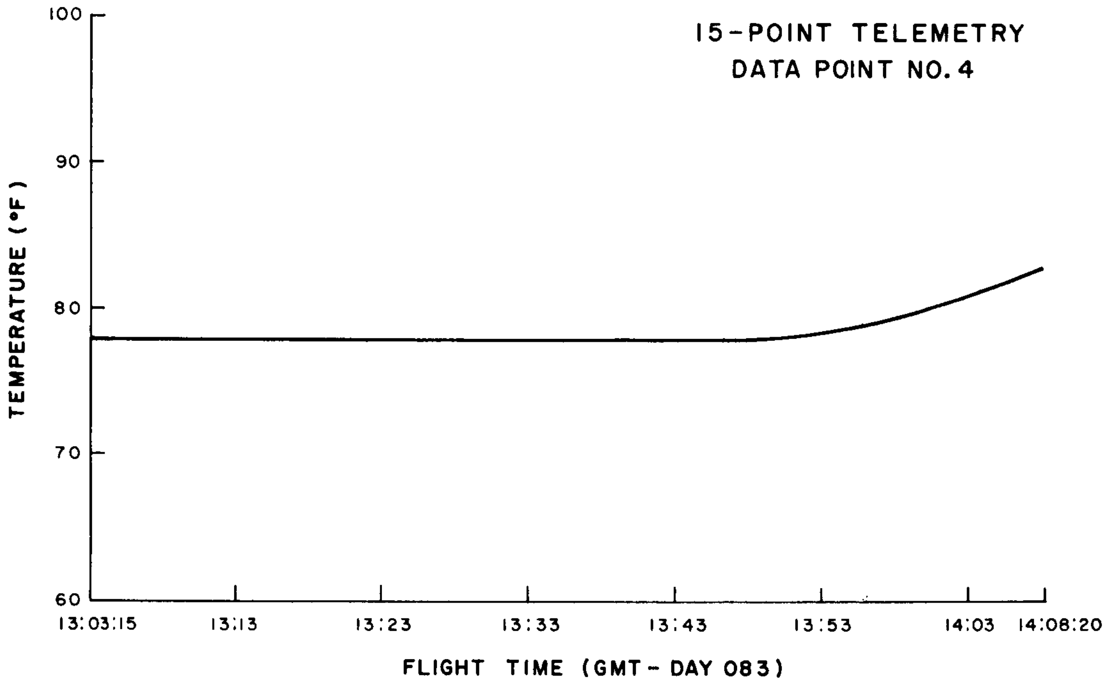


Figure 3-8. Actual P-Battery internal temperature during terminal mode as monitored by the 15-point telemetry

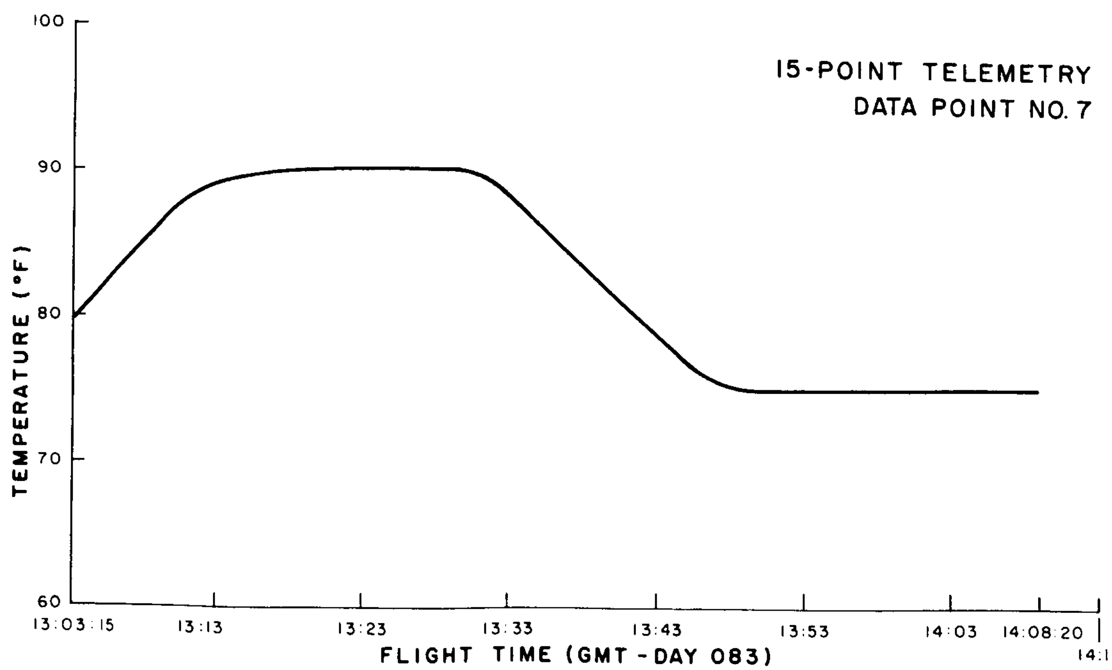


Figure 3-9. Actual Top Hat (Shroud) temperature during terminal mode as monitored by the 15-point telemetry

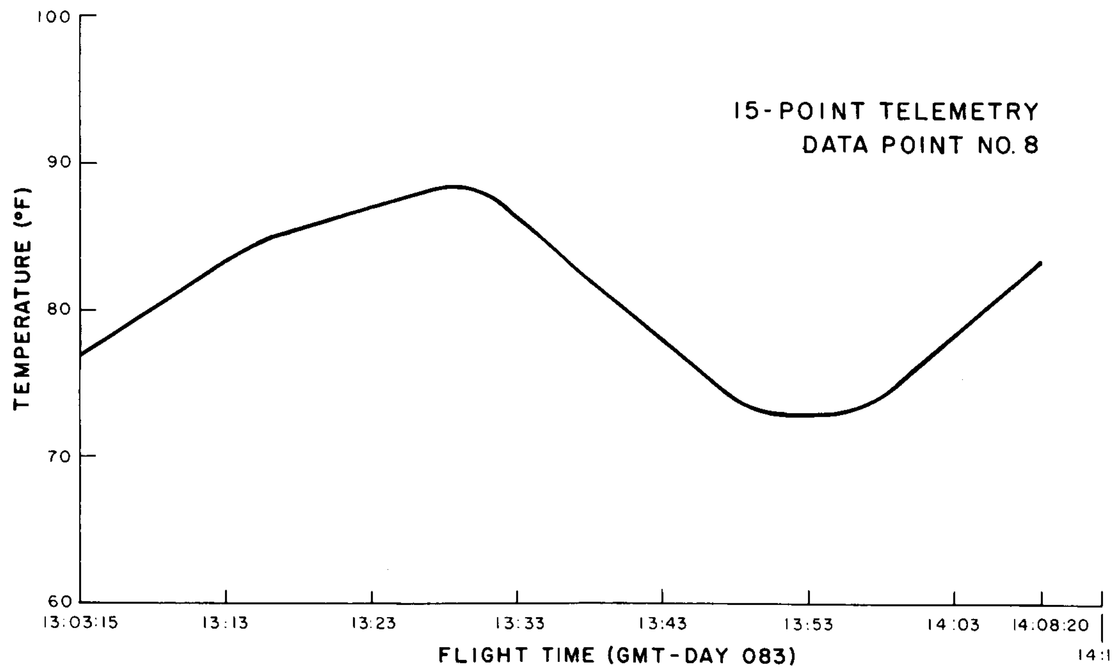


Figure 3-10. Actual Lower Shroud temperature during terminal mode as monitored by the 15-point telemetry

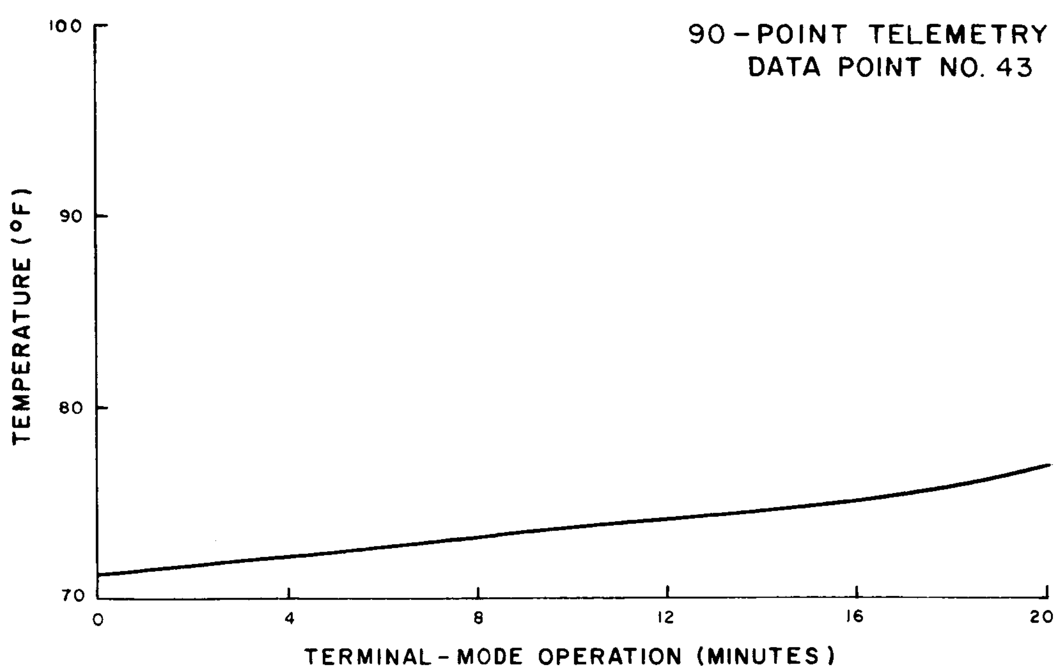


Figure 3-11. Actual F_b Camera Electronics temperature during terminal mode

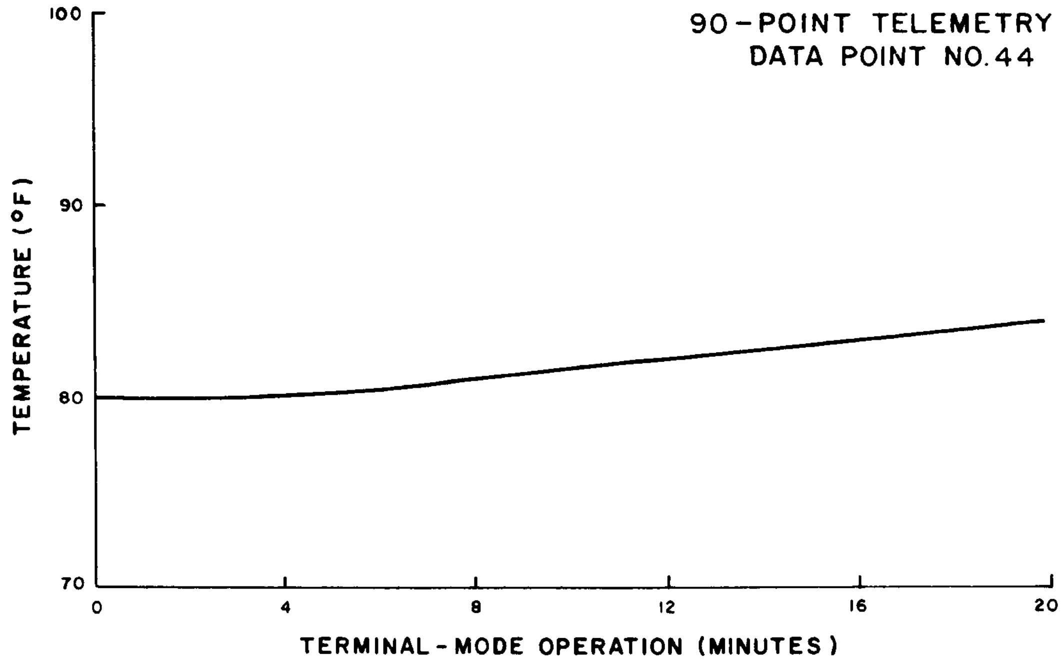


Figure 3-12. Actual F-Battery Case temperature during terminal mode

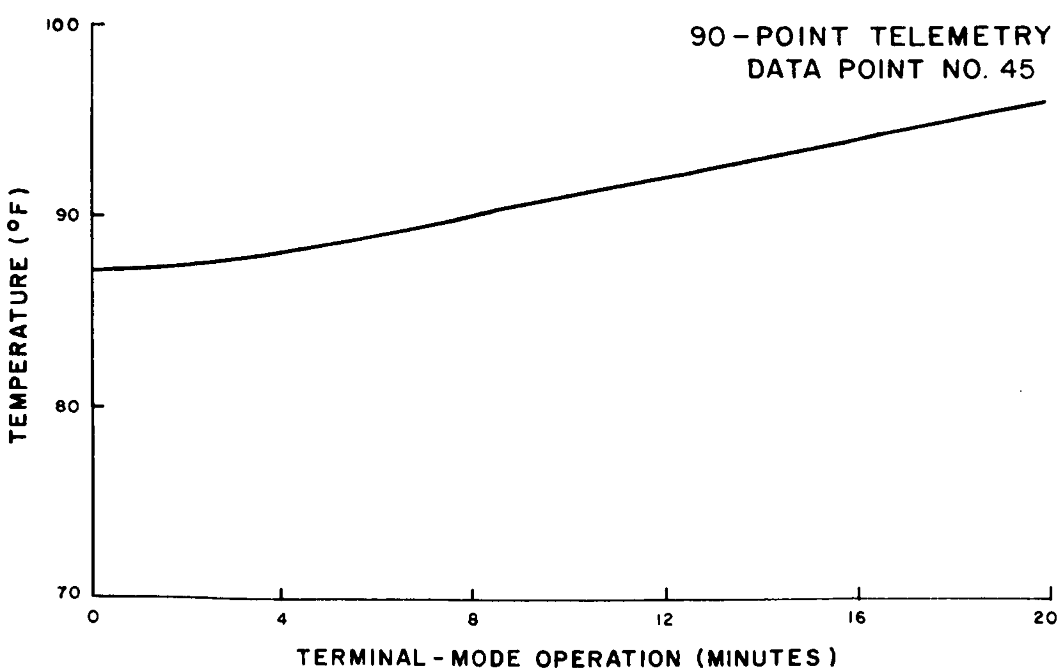


Figure 3-13. Actual P-Battery Case temperature during terminal mode

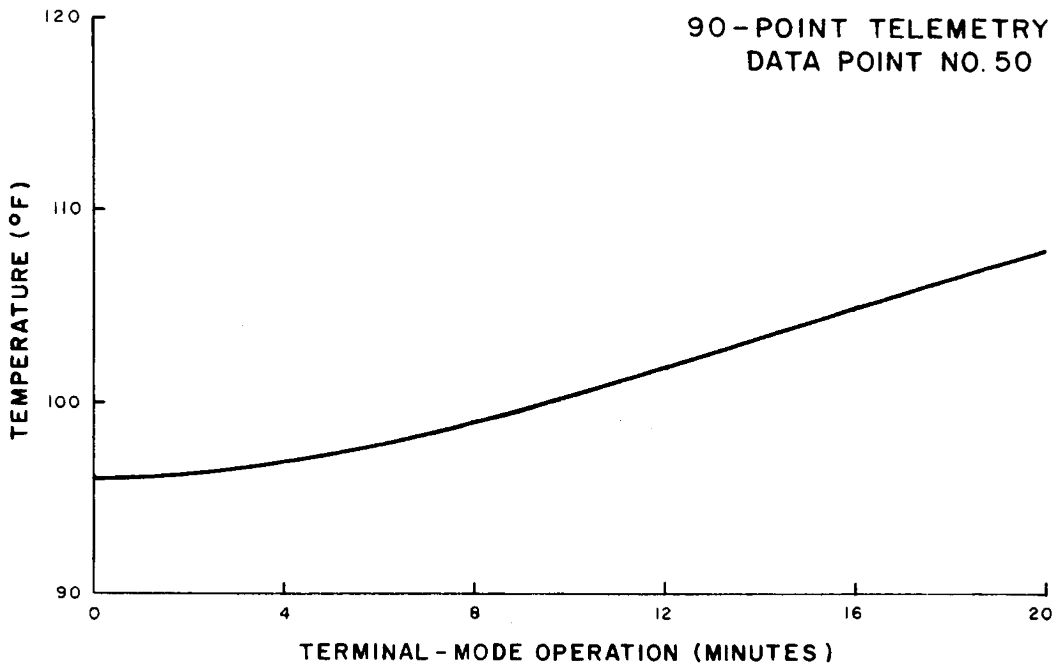


Figure 3-14. Actual Lower Shroud (+Y side) temperature during terminal mode

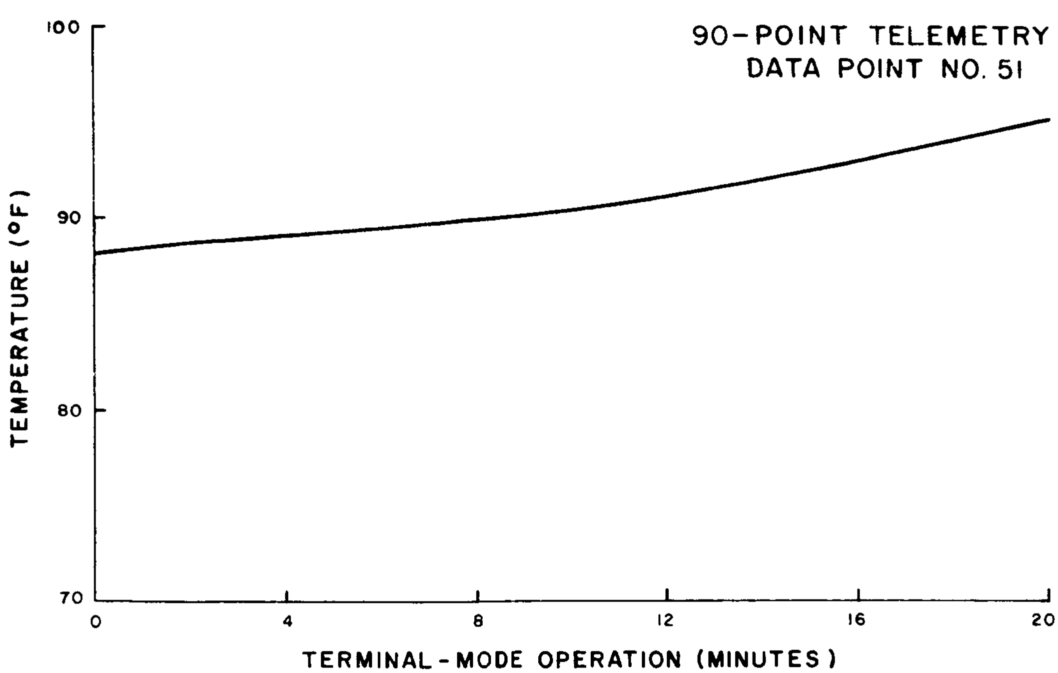


Figure 3-15. Actual Bottom Deck temperature during terminal mode

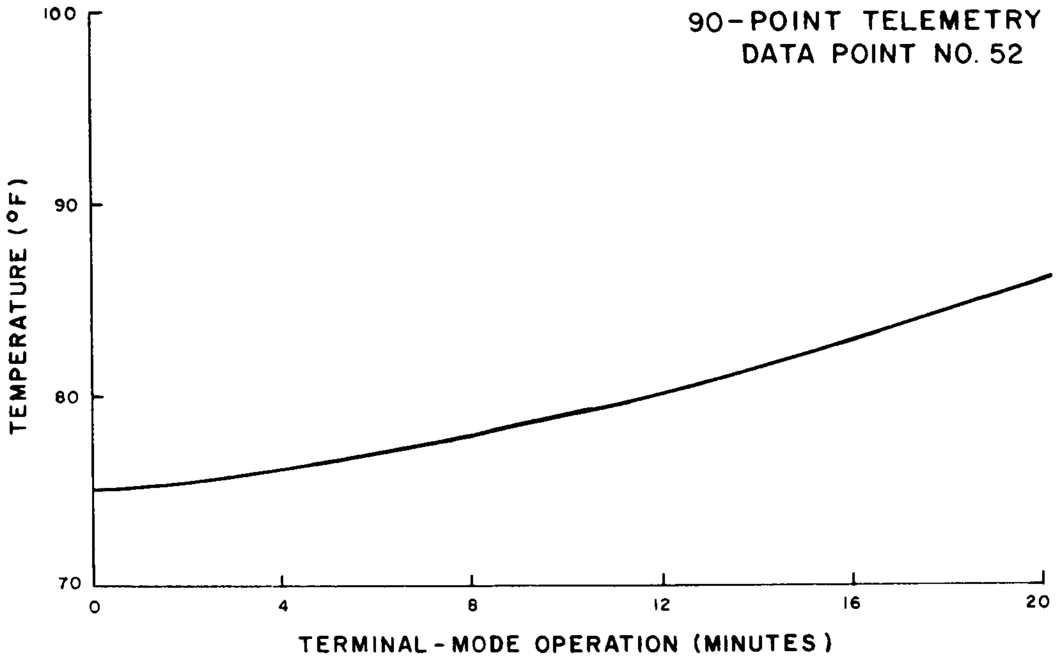


Figure 3-16. Actual Second Deck (–Y side) temperature during terminal mode

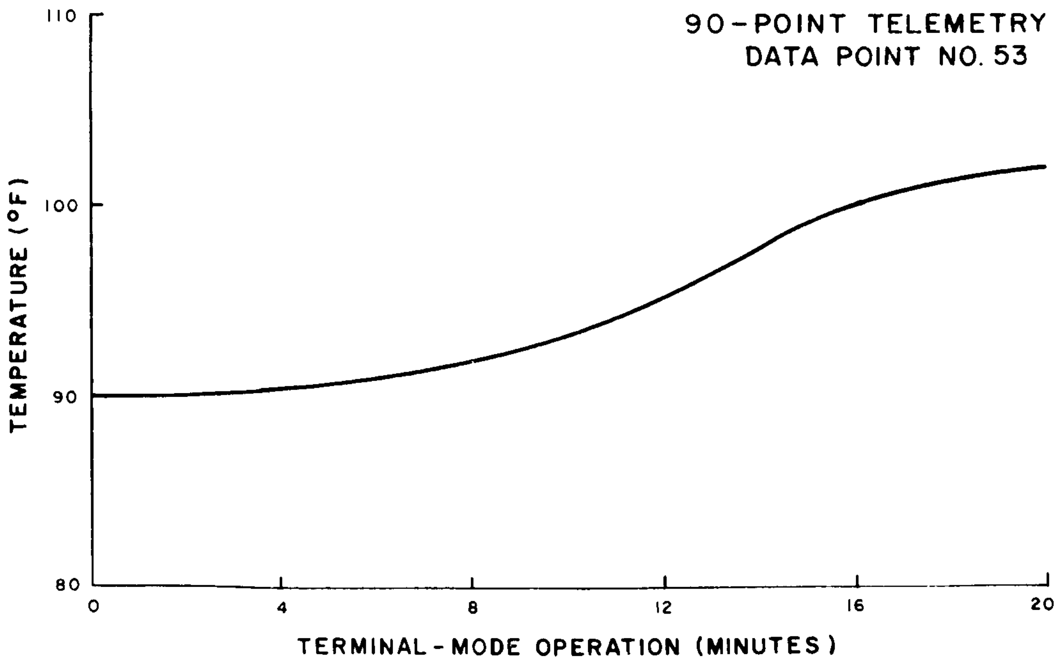


Figure 3-17. Actual Second Deck (+Y side) temperature during terminal mode

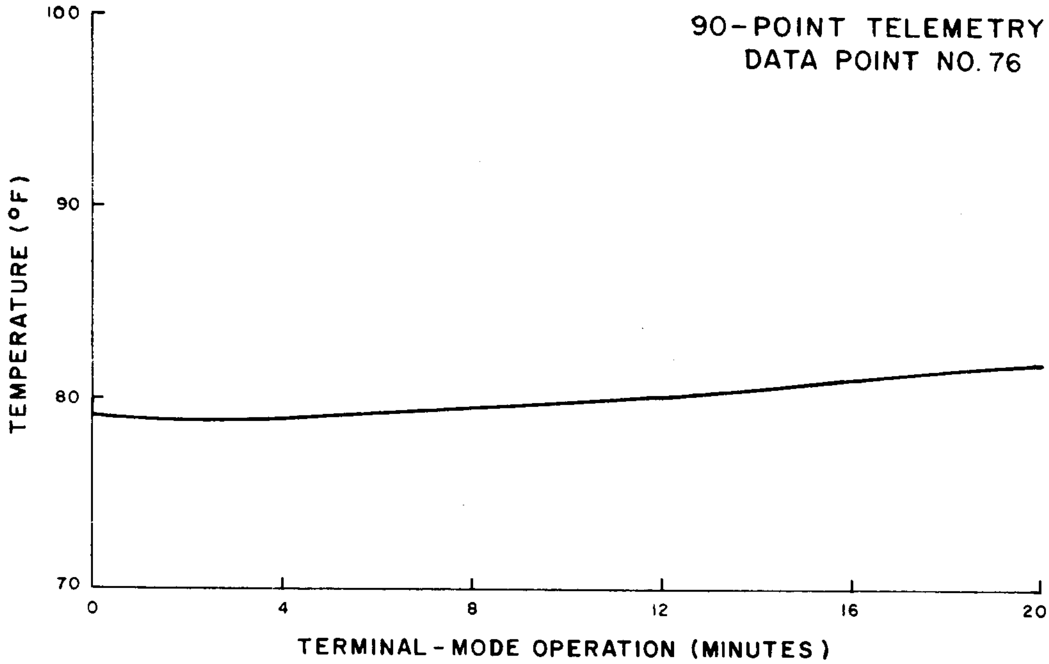


Figure 3-18. Actual P-Channel Transmitter Power Amplifier Heat-Sink temperature during terminal mode

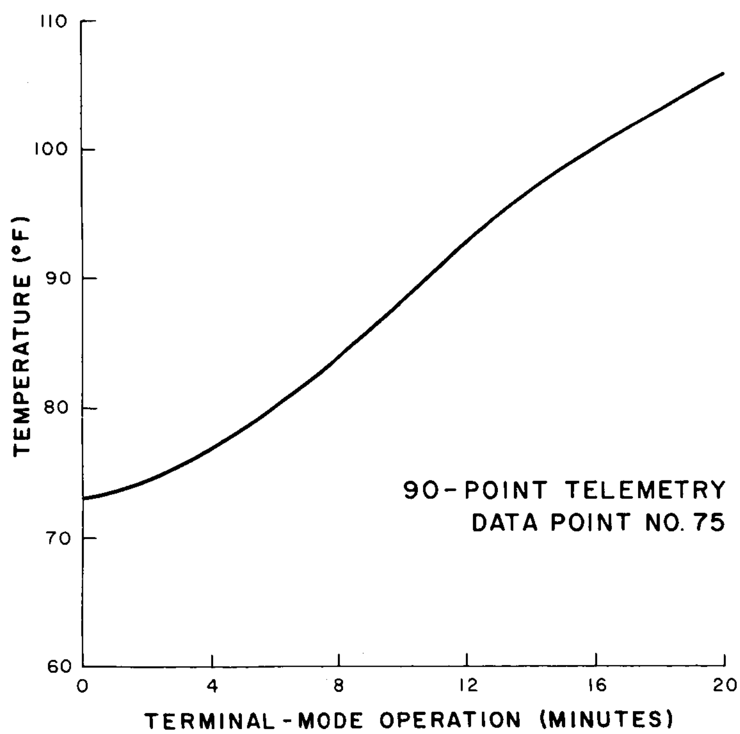


Figure 3-19. Actual F-Battery internal temperature during terminal mode

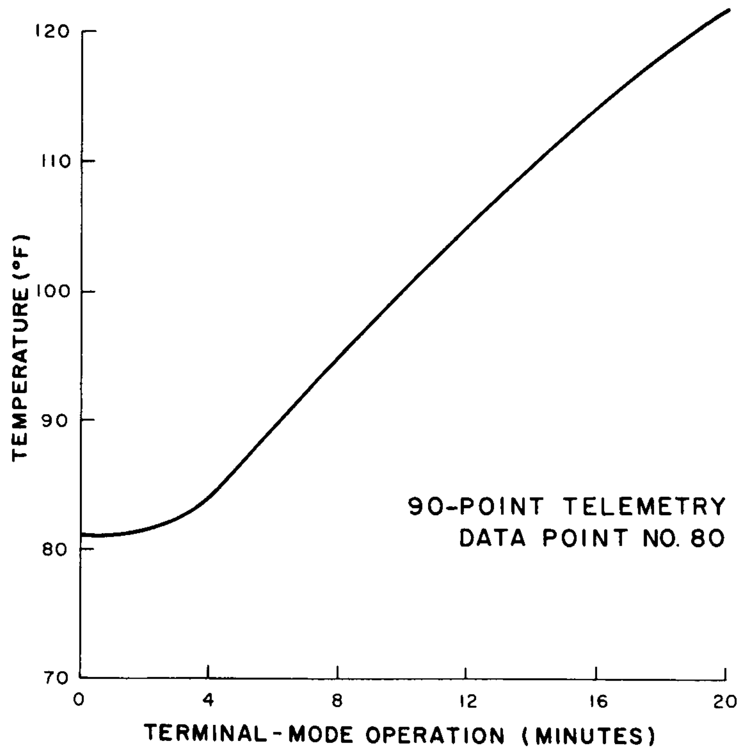


Figure 3-20. Actual F-Transmitter Power Amplifier Heat Sink temperature during terminal mode

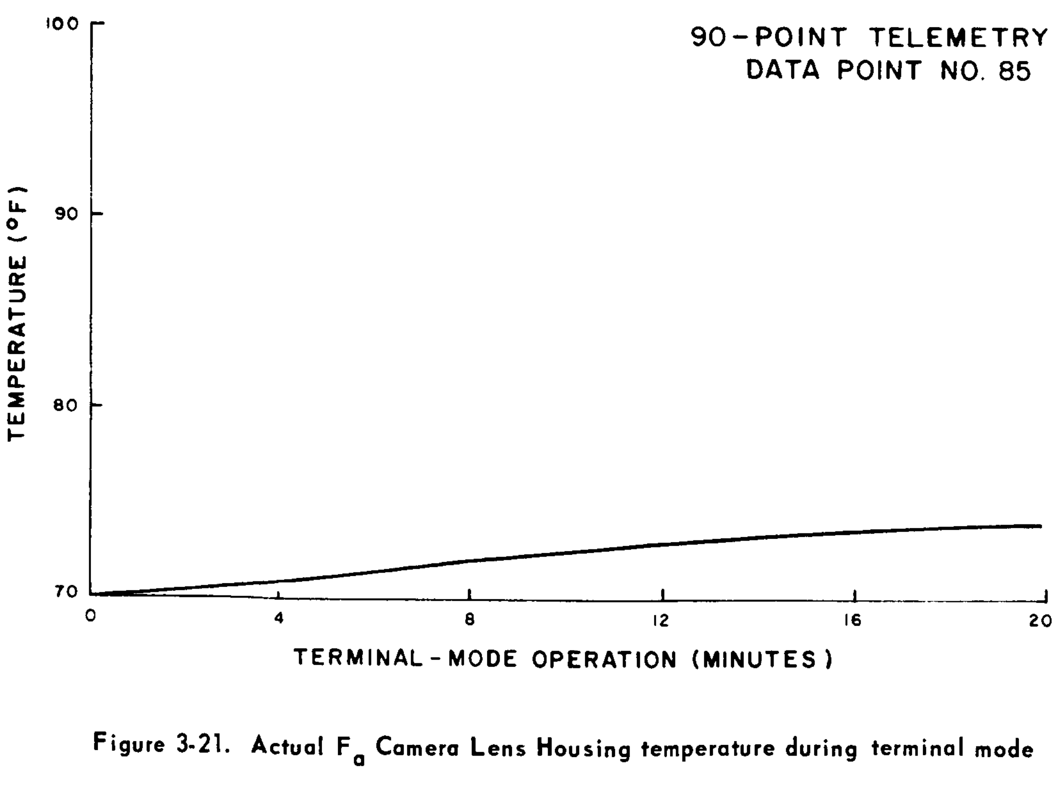


Figure 3-21. Actual F_a Camera Lens Housing temperature during terminal mode

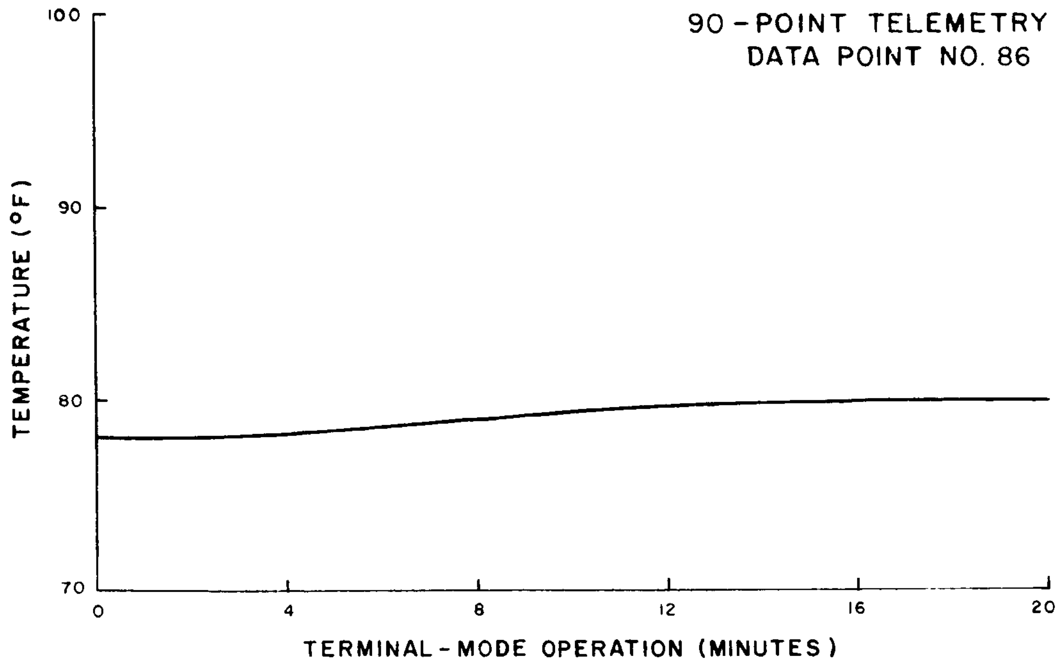


Figure 3-22. Actual Camera Bracket temperature during terminal mode

At the start of F-Channel warmup, the 90-point telemetry data were switched onto Channel 8. The signal profile from the full-power command data points Nos. 55 and 60 indicated that both channels went into warmup mode for 80 seconds and then each channel was turned on into full-power operation by the associated Camera Sequencer. The telemetry data indicated normal supply voltages and operating temperatures for both transmitter channels. The Power Amplifier cathode-current profiles for the transmitters were almost identical to prelaunch full-power tests confirming a high-power output for both channels. All telemetry indications for the TV camera equipment were normal.

The telemetry data for the F-Channel Video Combiner output is shown in Figure 3-23. This data point, No. 74 of the 90-point telemetry, measures the amplitude of the composite video signal, which has a range of 1.5 volts from sync tip to peak white for each camera, at the video combiner output and indicates that a video signal is being applied to the modulator input. Its use to establish scene luminance is limited, because it monitors two cameras that have a four-to-one difference in their dynamic ranges and the data sample had not been calibrated with the cameras. The telemetry data for the output of the P-Channel Video Combiner (data point No. 72 of the 90-point telemetry) are presented in Figure 3-24.

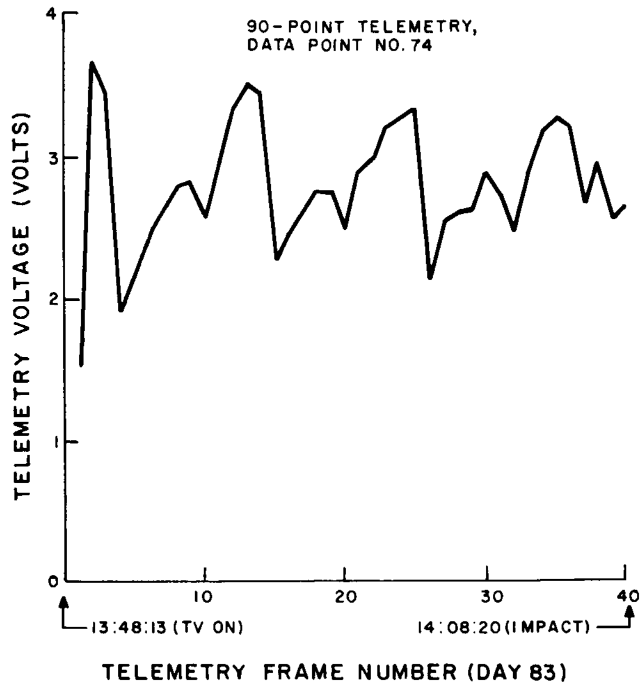


Figure 3-23. F-Channel Video Combiner output during terminal mode

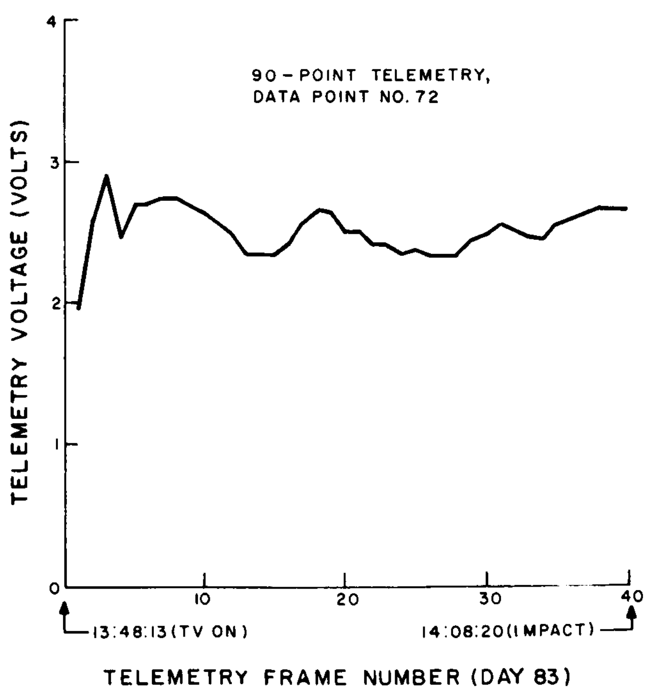


Figure 3-24. P-Channel Video Combiner output during terminal mode

The performance of the TV Subsystem telemetry was nominal throughout the mission. The 90-point commutator stopped on data point No. 69 at the end of the prelaunch test and started on the same point at terminal mode signifying no movement of the commutator during cruise mode.

During the terminal mode, there was a momentary interruption of the JPL-provided Channel 8 analog telemetry for 13 seconds (day 083 - 13:58:06 to 13:58:19 GMT); F-Channel and P-Channel telemetry were uninterrupted.

It can be stated that the Ranger TV Subsystem performance during the 64 hours 31 minutes 18 seconds of the Ranger IX lunar mission was normal. All operating parameters were within design specifications, and all cameras and systems exceeded specification requirements.

B. Ground Support Equipment (GSE)

1. Prelaunch and Pretrack Preparation

Approximately 72 hours before launch of the RA-9 Spacecraft, a complete alignment of the Ranger Ground Support Equipment (GSE) at the Echo site (DS1F-12) and Pioneer site (DS1F-11) of the Goldstone Tracking Station was initiated. This alignment was performed in accordance with the procedures of Ranger specification Nos. RTSP-1200A, RTSP-1220A, Appendix B, and RTSP-1240C, as specified in Ranger Operational Procedure No. ROP-1. The data from the alignment procedures were submitted to JPL more than 24 hours before launch. No discrepancies were noted in any of the test data obtained.

After launch, an abbreviated check of overall GSE operation was performed before each pass of the RA-9 Spacecraft over the Goldstone Tracking Station. The pretrack checkouts were performed in accordance with Ranger Operational Procedure ROP-2. No discrepancies were noted in the test data obtained.

2. Film Recorder Calibration

a. Cathode Ray Tube (CRT) Evaluation

Prior to the RA-8 mission, eight cathode ray tubes (CRT) were designated for mission or backup utilization based on a history of performance as determined by a series of grid drive/film density and overall response test runs.

For the RA-9 mission, the validity of CRT performance was confirmed by the analysis of a series of evaluation tests performed in the interim between the RA-8 and RA-9 operations. All 35-mm film for the evaluation was developed to a gamma of 1.40.

Evaluation of the test data, with respect to repeatibility and optimization of CRT operating conditions, initially determined the classification of the CRT's as either mission or backup units. The classification and assignment of the CRT's, prior to flight-model film calibration, are listed in Table 3-5. Figures 3-25 through 3-28 are typical curves of 35-mm film density as a function of grid drive obtained for the mission CRT's. Calibration curves were available for all CRT's should a change in tube classification become necessary.

TABLE 3-5
CATHODE RAY TUBE ASSIGNMENT AND CLASSIFICATION FOR RA-9 MISSION

Film Recorder Number	Mission CRT		Backup CRT	
	Serial No.	Camera Lens f-Stop No.	Serial No.	Camera Lens f-Stop No.
1	2804	5.6	1294	4.0
2	4211	3.5	3012	3.5
3	2866	5.6	027	5.6
4	4207	3.5	028	3.5

b. Flight-Model Film Calibration

After the initial curves for film density as a function of grid-drive were obtained and the mission CRT's were designated, the G2 grid-drive conditions were determined for each mission CRT. A magnetic tape recording of the RA-9 camera-calibration data obtained at the Eastern Test Range (ETR) was utilized for this operation. The film-development gamma and CRT operating parameters (other than the G1 grid) were held constant, and the gain and bias level were adjusted to obtain the proper film densities for black and peak-white video levels using the following procedure:

- Black was defined as the lowest video signal (peak-to-peak voltage from sync tip) obtained with the TV camera lens capped. The G1 bias of the CRT was then adjusted to obtain a 35-mm film density of 0.4 ±0.05 for that video signal, using the extended-field-source (EFS) test patterns on the RA-9 camera calibration tape;

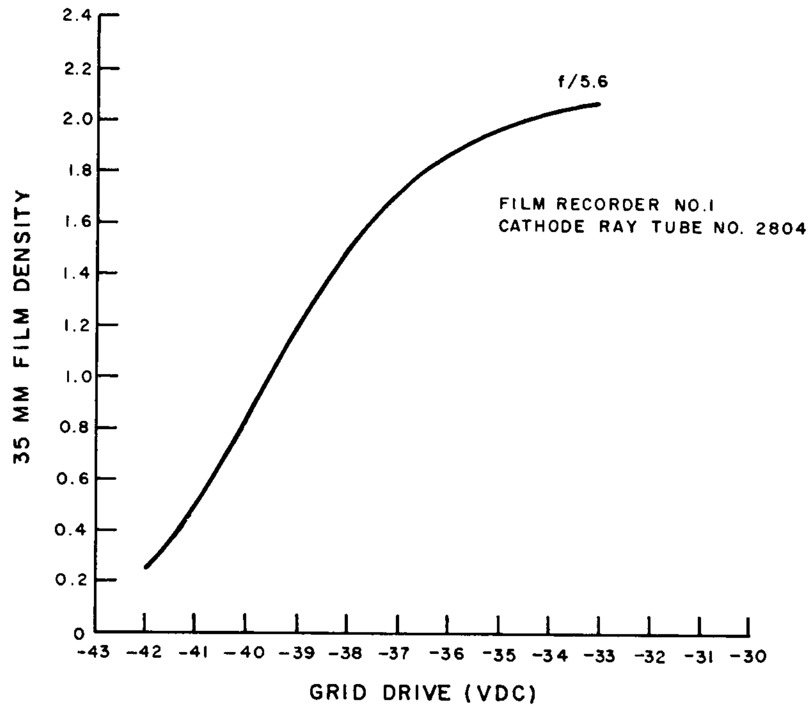


Figure 3-25. 35-mm film density as a function of CRT grid drive for Film Recorder No. 1

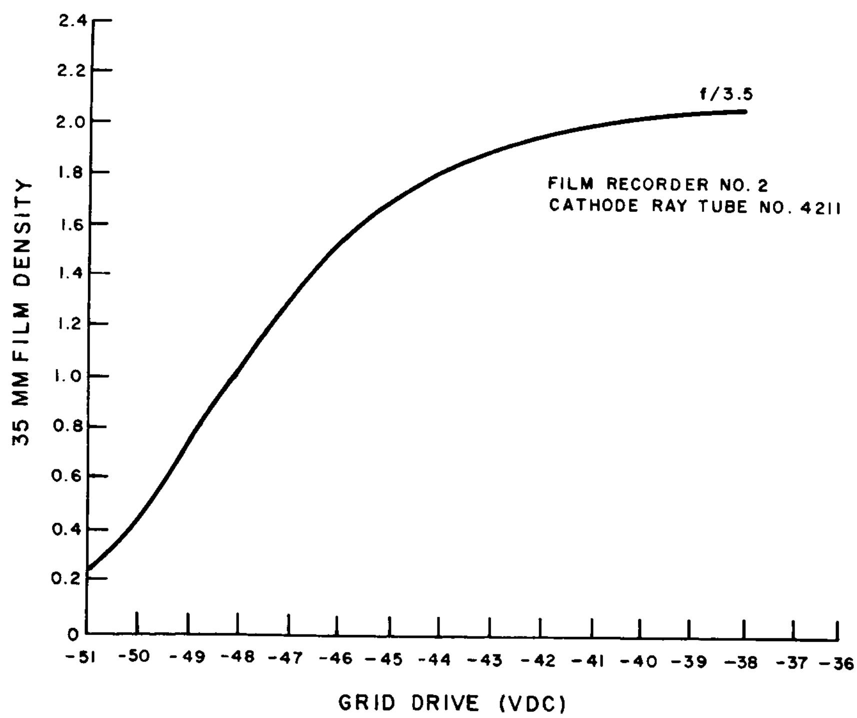


Figure 3-26. 35-mm film density as a function of CRT grid drive for Film Recorder No. 2

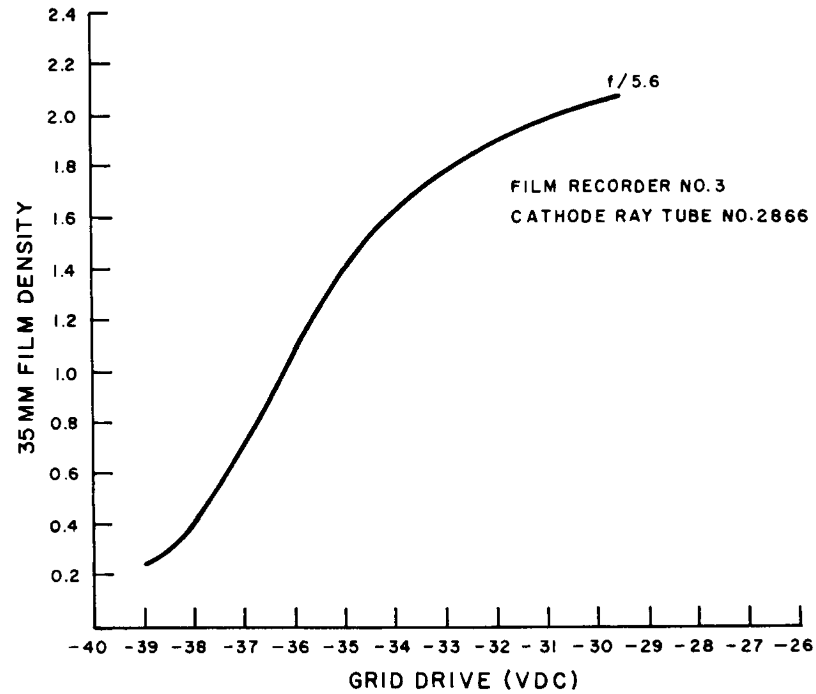


Figure 3-27. 35-mm film density as a function of CRT grid drive for Film Recorder No. 3

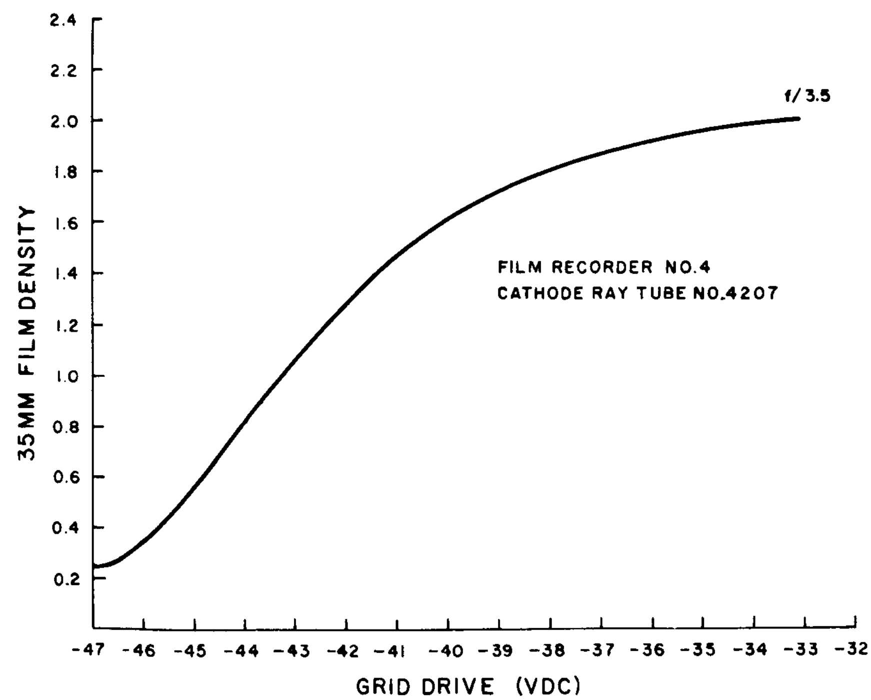


Figure 3-28. 35-mm film density as a function of CRT grid drive for Film Recorder No. 4

- Peak white was defined as the highest peak-white signal (peak-to-peak voltage from sync tip) presented on the EFS patterns for whites. The G1 gain of the CRT was then adjusted to obtain a 35-mm film density of 1.9 ±0.1 for that video signal.

Film Recorders Nos. 1 and 3 were adjusted for the F_a and F_b Cameras, and Film Recorders Nos. 2 and 4 were adjusted for the P1, P2, P3, and P4 Cameras. Film Recorders Nos. 1 and 2 were located at the Echo site (DSIF-12), and Film Recorders Nos. 3 and 4 at the Pioneer site (DSIF-11).

For the RA-9 mission, the peak-white levels of the F_b and P1 Cameras and the peak-black levels of the F_b and P3 Cameras were used for final calibration of the film recorders. Figures 3-29 through 3-32 present the light-transfer curves for the four flight film recorders and express the 35-mm film density as a function of the illumination on the vidicons of the RA-9 cameras.

3. Post-Impact Data Handling

The initial RA-9 data reproduction was performed immediately after impact. Several changes were made to Ranger Operational Data-Handling Procedure ROP-4. The most important procedural change consisted of obtaining the 35-mm film copy of the RA-9 camera-calibration tapes (total of 7) prior to the start of the last pass of RA-9 over the Goldstone station. This change reduced the data-reproduction time to a minimum and provided the project scientist with 35-mm film data several hours sooner after impact than during the RA-8 mission.

The RA-9 data was reviewed and the only problem evident consisted of a scratch over a length of 35-mm film from Film Recorder No. 2. A similar scratch also appeared on the prime original data (POD) film No. 2 from this film recorder. The pre-track test did not indicate any problem of this type. Investigation of the 35-mm camera mounted on Film Recorder No. 2 revealed that the pressure plate adjustment was too high. The adjustment of the pressure plate was reduced and a subsequent film reproduction was completed without scratching the film.

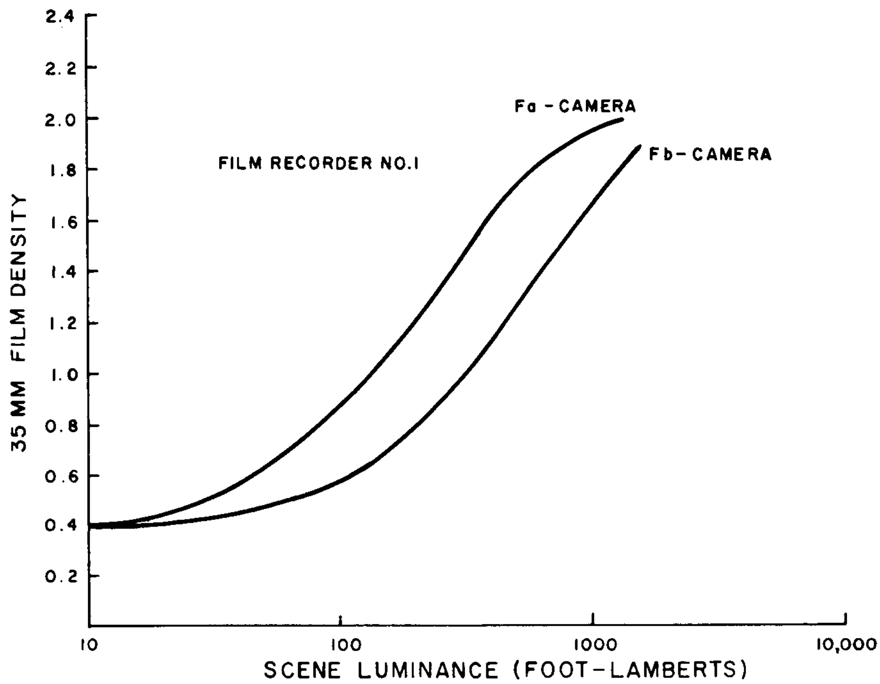


Figure 3-29. 35-mm film density as a function of scene luminance for RA-9 full-scan cameras for Film Recorder No. 1

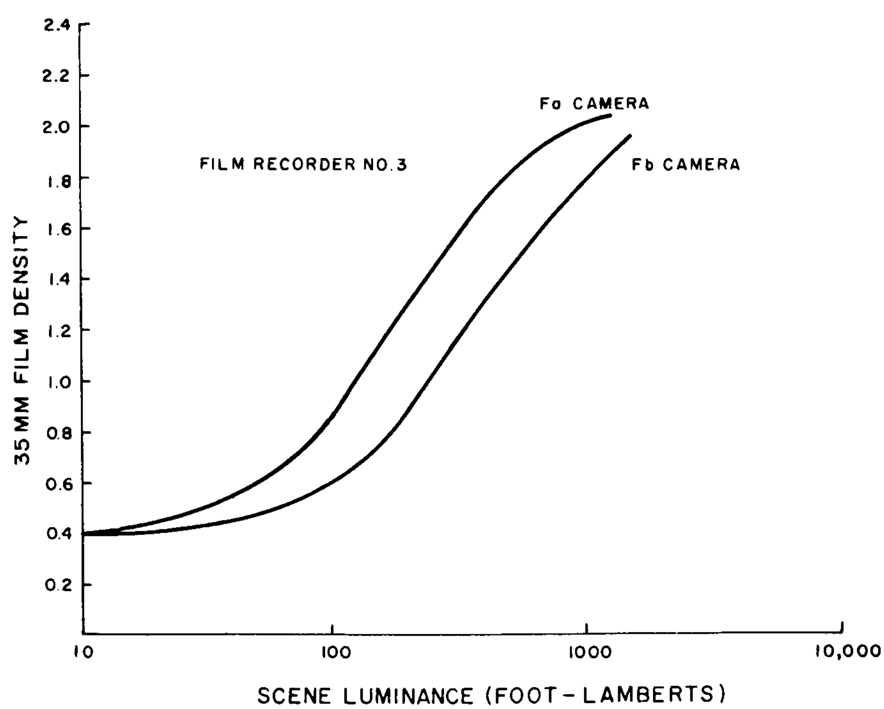
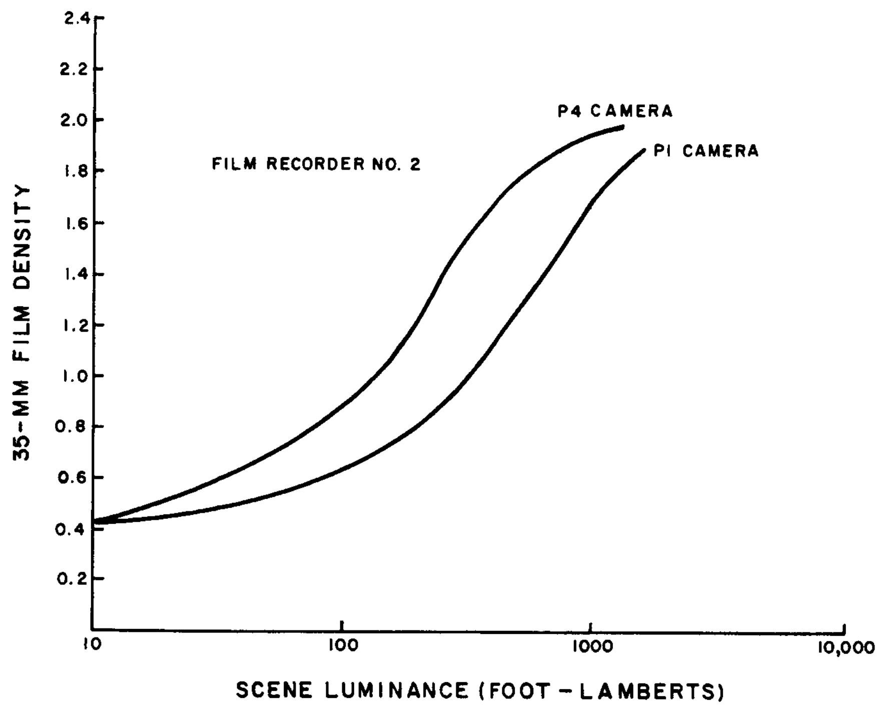
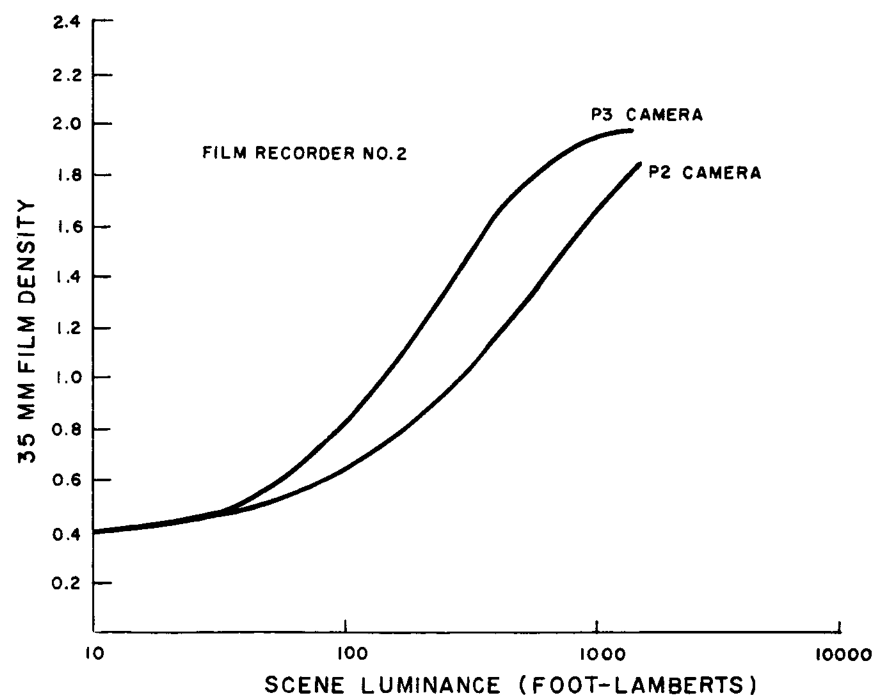


Figure 3-30. 35-mm film density as a function of scene luminance for RA-9 full-scan cameras for Film Recorder No. 3

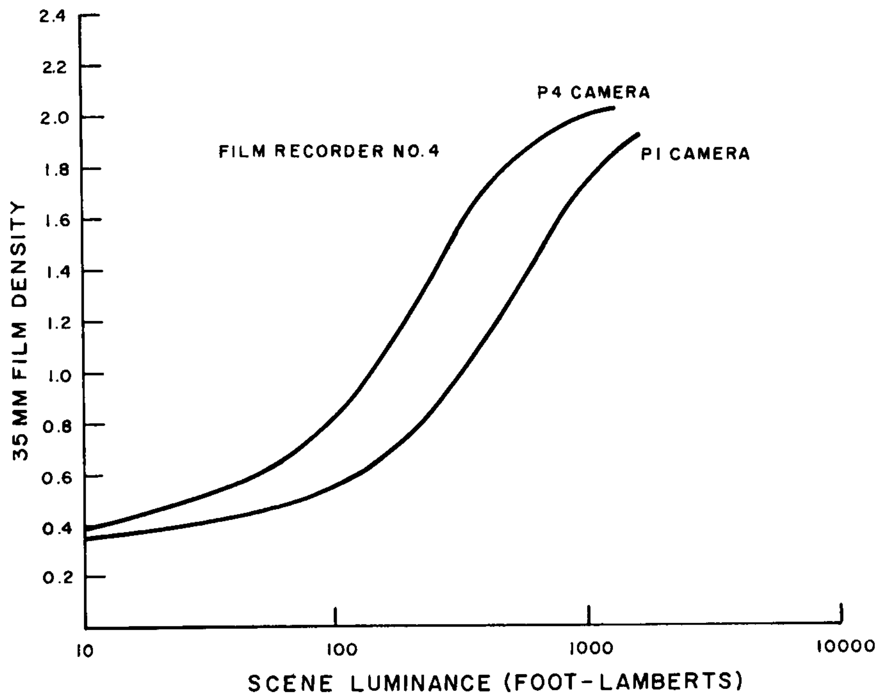


a. P1 and P4 Cameras

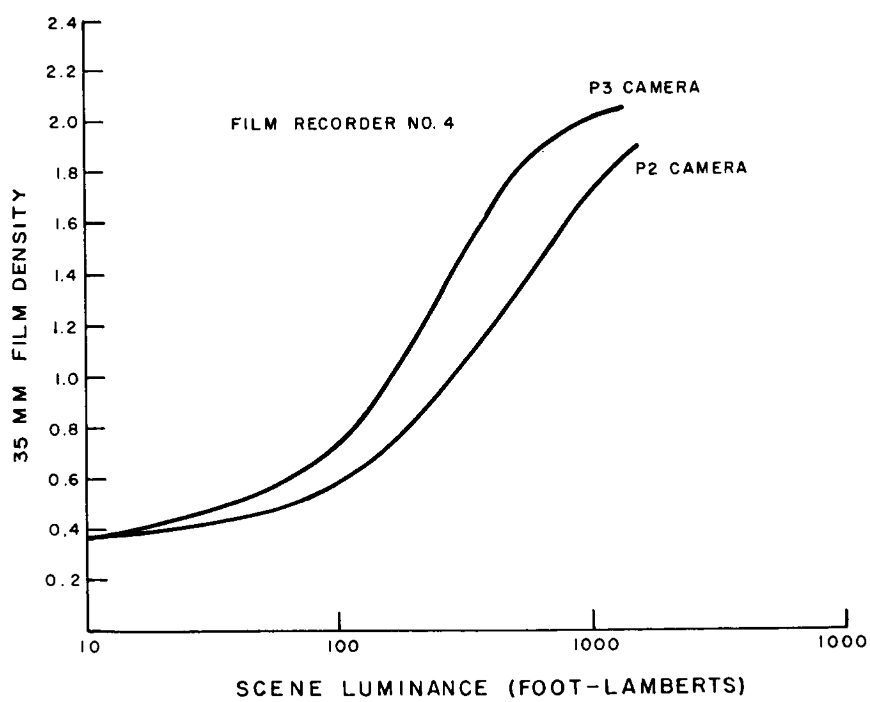


b. P2 and P3 Cameras

Figure 3-31. 35-mm film density as a function of scene luminance for RA-9 partial-scan cameras for Film Recorder No. 2



a. P1 and P4 Cameras



b. P2 and P3 Cameras

Figure 3-32. 35-mm Film density as a function of scene luminance for RA-9 partial-scan for Film Recorder No. 4

Section IV

Flight Model III-4 (RA-9) Equipment Performance

A. General

Every aspect of the performance of the Flight Model III-4 TV Subsystem during the Ranger IX mission achieved or exceeded specification requirements. The countdown, launch, and cruise phases of the mission, as evaluated from the 15-point telemetry, very closely followed the predicted levels of operation. The terminal phase of the mission, from the initiation of warmup until impact, produced results which exceeded all expectations. A terminal maneuver was performed which aligned the common optical axis of the cameras with the Spacecraft velocity vector, thereby allowing for excellent picture nesting and almost eliminating image smear. The Electronic Clock was reset by means of a RTC-5 command to allow for the initiation of warmup of the TV Subsystem by means of a CC&S command at a time which was essentially ideal to provide area identification and also ensure continuing operation until impact.

The performance of the Camera equipment, as well as the transmission link to Earth. can best be adjudged by the evaluation of the mission film and magnetic-tape records. There exists unanimous agreement that the received picture quality far exceeded all expectations. A detailed discussion of Camera equipment performance is presented in Paragraph B of this section.

The thermal profile during the mission closely approximated the predicted values. No abnormalities were experienced. It was noted that temperature changes were experienced during the terminal maneuver of the Spacecraft. Since this is the first mission to employ a terminal maneuver, no prior mission data of this nature have been previously available. The evaluation of thermal control is based on the received telemetry. An evaluation of the thermal control equipment and a correlation of the predicted mission temperatures with those actually experienced are presented in Paragraph C.

The communications equipment performance, evaluated by picture quality, video signal levels, and signal strength as measured during the mission, was excellent. An analysis of the r-f power level, frequency stability, and deviation in the two high-power transmitters, and a summary of the telemetry system performance are given in Paragraph D.

The command and control equipment operated flawlessly throughout the RA-9 mission. This equipment is evaluated in Paragraph E. Special attention is given to the use of the in-flight reset capability of Electronic Clock by means of an RTC-5 command for the first time during a mission.

The power equipment including the batteries and the associated regulators performed equally well during the RA-9 mission. No shortcomings in regards to performance were detected. An analysis of performance of this equipment, based on a study of the received telemetry data, is contained in Paragraph F.

B. Camera Group

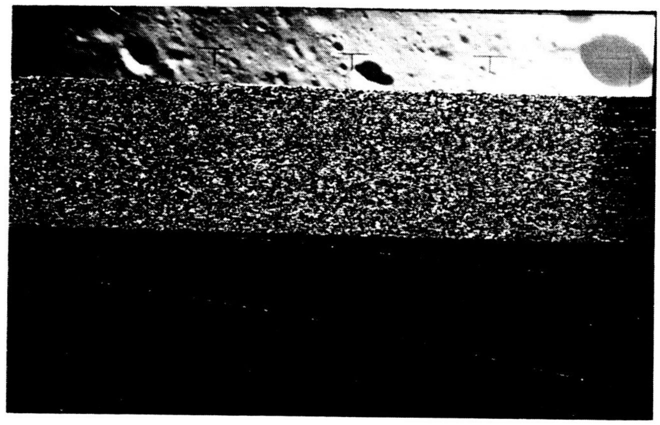
1. Picture Analysis

The mission requirements of high-resolution pictures of the lunar surface and of picture nesting were achieved by the Ranger-IX Spacecraft.

The TV Subsystem sent back 5866 pictures during the approximate 19-minute terminal-mode operation: 5422 pictures were taken by the partial-scan cameras, and 444 pictures by the full-scan cameras. The images on the F_b and P3 Cameras were being scanned at impact. Figures 4-1 and 4-2 show the extent of information that was received from these cameras before impact. Figures 4-3 and 4-4 show the amplitude of the last line of video information for the F_b and P3 Cameras. The minimum resolvable crater size in these pictures is given in Table 4-1. The minimum resolvable crater size in the last complete pictures of all of the cameras is given in Table 4-2.

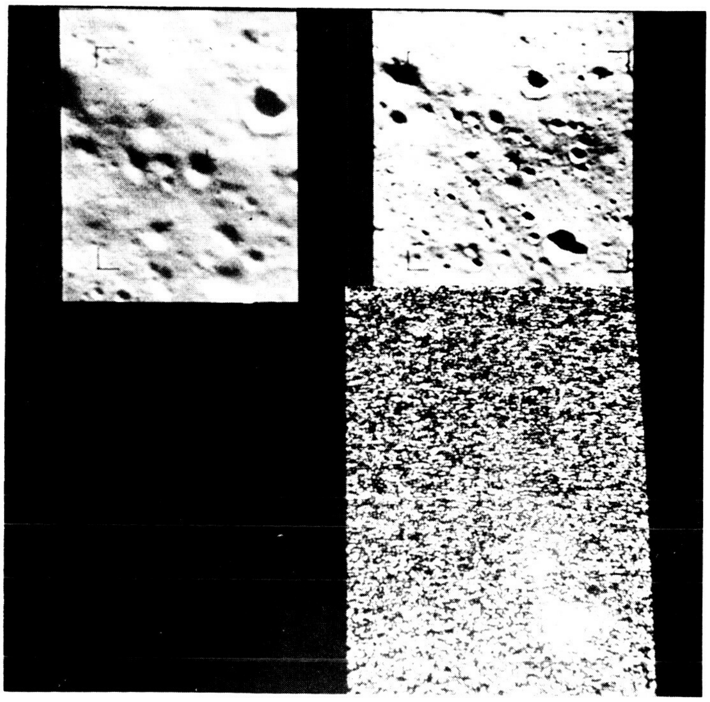
TABLE 4-1
MINIMUM RESOLVABLE CRATER SIZE IN FINAL F_b AND P3 CAMERA PICTURES

Camera	Time Before Impact (seconds)	Altitude (feet)	Approximate Area Covered at Exposure (sq. ft.)	Approximate Minimum Crater Diameter (feet)
F_b	0.411	3267	640 x 550	1.4
P3	0.253	2000	250 x 225	2.5



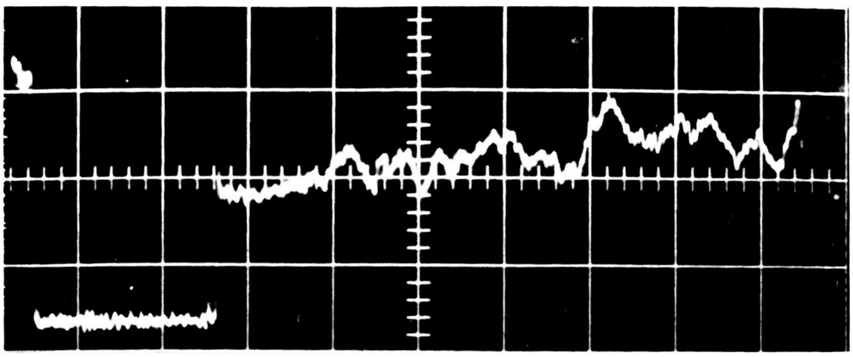
APPROXIMATELY 300-MS READ-OUT TIME (FRAME TIME: 2.56 SECS)

Figure 4-1. Final picture taken by the F_b Camera



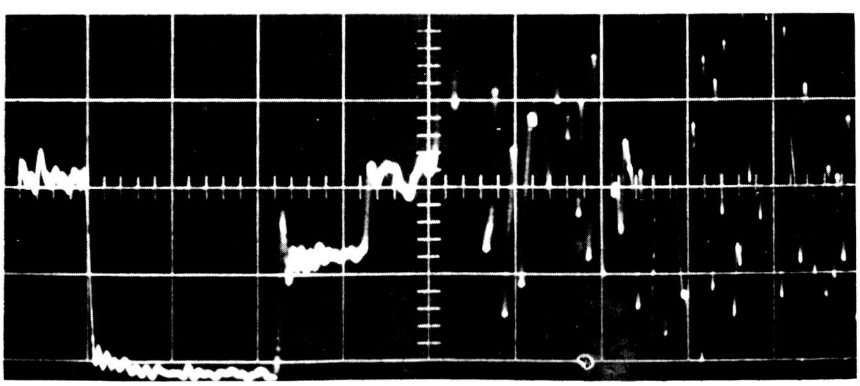
APPROXIMATELY 190-MS READ-OUT TIME (FRAME TIME: 200 MS)

Figure 4-2. Final pictures taken by the P1 and P3 Cameras



HORIZONTAL SCALE: 100 μSEC/CM VERTICAL SCALE: 250 MV/CM

Figure 4-3. Last line of video information transmitted by the RA-9 L_b Camera



HORIZONTAL SCALE: 50 μSEC/CM VERTICAL SCALE: 250 MV/CM

Figure 4-4. Last line of video information transmitted by the RA-9 P3 Camera

TABLE 4-2 MINIMUM RESOLVABLE CRATER SIZE IN LAST COMPLETE PICTURES				
Camera	Time Before Impact Seconds	Altitude (miles)	Approximate Area Covered	Approximate Minimum Crater Diameter (feet)
P1	0.453	0.785	155 x 115 ft.	1.7
P2	0.893	1.35	310 x 275 ft.	3.5
P3	1.06	1.65	1100 x 1000 ft.	11.5
P4	0.693	1.1	725 x 625 ft.	8
F_a	2.97	4.5	2.1 x 1.9 mi.	25
F_b	5.53	8.3	1.6 x 1.4 mi.	20

The terminal maneuver aligned the common optical axis of the TV cameras along the Spacecraft velocity vector providing excellent camera nesting as shown in Figures 4-5 to 4-10.

2. Evaluation of Camera Performance

In general, the performance of the cameras during the mission was similar to that experienced during tests. A comparison of camera performance during the mission and during testing is given in Table 4-3.

TABLE 4-3 COMPARISON OF CAMERA PERFORMANCE DURING THE RA-9 MISSION AND TEST		
Camera	Mission Performance	Test Performance
	Microphonics	
P_1	Very low-level microphonics in many frames, but of negligible magnitude.	Self-induced nuvistor microphonics were observed during various tests, apparently becoming more serious during tests at ETR.
	Occasional, but pronounced vidicon microphonics induced by an F-Camera shutter.	F-Camera shutter-induced microphonics, often severe, occurred randomly during tests

TABLE 4-3
COMPARISON OF CAMERA PERFORMANCE DURING THE RA-9 MISSION AND TEST
(Continued)

Camera	Mission Performance	Test Performance
Microphonics (Continued)		
P2	Vidicon microphonics, induced by the shutter of the P4 Camera, apparent in a majority of the frames.	This camera always exhibited the tendency for P4 shutter-induced vidicon microphonics.
P3	Three frames showed F-Camera shutter-induced microphonics	Very infrequent and low-level microphonics induced primarily from an F-Camera shutter
P4	Six frames showed F-Camera shutter-induced vidicon microphonics	Occasional low-level, self-induced nuvistor microphonics, and random F-Camera shutter-induced vidicon microphonics
F_a	Vidicon microphonics induced by P4-Camera shutter	Microphonics, approximately 100 to 150 mv, were observed after integration on RA-9
F_b	None observed	None observed
Shutter-Induced Noise Bursts		
		(Horizontal Shutter Plane Test)
P1	None observed	None observed
P2	Approximately 15% of the frames had noise spikes of approximately 5-microsecond duration	Approximately 25% of the frames had shutter-induced noise bursts of short duration
P3	Less than one percent of the frames had shutter-induced noise bursts	Approximately 1.25% of the frames had noise bursts caused by either an F-Camera shutter or its own shutter
P4	Approximately 1.5% of the frames had noise bursts caused by either an F-Camera shutter or its own shutter	About 4% of total frames had noise bursts caused by either an F-Camera shutter or its own shutter

TABLE 4-3 COMPARISON OF CAMERA PERFORMANCE DURING THE RA-9 MISSION AND TEST (Continued)		
Camera	Mission Performance	Test Performance
Frames with Missing Lines		
P2	Less than 2% of the frames had missing lines	None observed
P4	Less than 1% of the frames had missing lines	Approximately 4% of the frames had missing lines

a. Image Degradation

During the overall RA-9 test cycle, shutter noise bursts were very prominent in the P1 and P2 Cameras and were to a much lesser extent in the P3 and P4 Camera. These bursts when they occur during the scan of video information appear as short white segments in a particular line. When a burst occurs during the clamp portion of a horizontal scan line, the video output for that line is driven to the black clip level and the entire line appears as a black line, resulting in a loss of information. Throughout the RA-9 mission, the total effect of these shutter-induced noise bursts was negligible.

The Ranger IX Cameras maintained excellent resolution throughout the test cycle. An example of this performance is shown in Table 4-4. This table shows limiting resolution as determined from the camera response to RETMA patterns, viewed via 35mm film. These tests were performed at JPL. The results of the thermal-vacuum test were selected as an example since the thermal-vacuum test is the most severe of all

TABLE 4-4
CAMERA RESOLUTION DURING THERMAL-VACUUM TESTING

Camera	Door Test (Ambient) (TVL)	Thermal-Vacuum Test 36°C (98°F) (TVL)	Thermal-Vacuum Test 13°C (53°F) (TVL)
P_1	200	200	200+
P_2	225	225	220
P_3	245	210	245
P_4	260	210	245
F_a	750	725	775+
F_b	775	750	775+

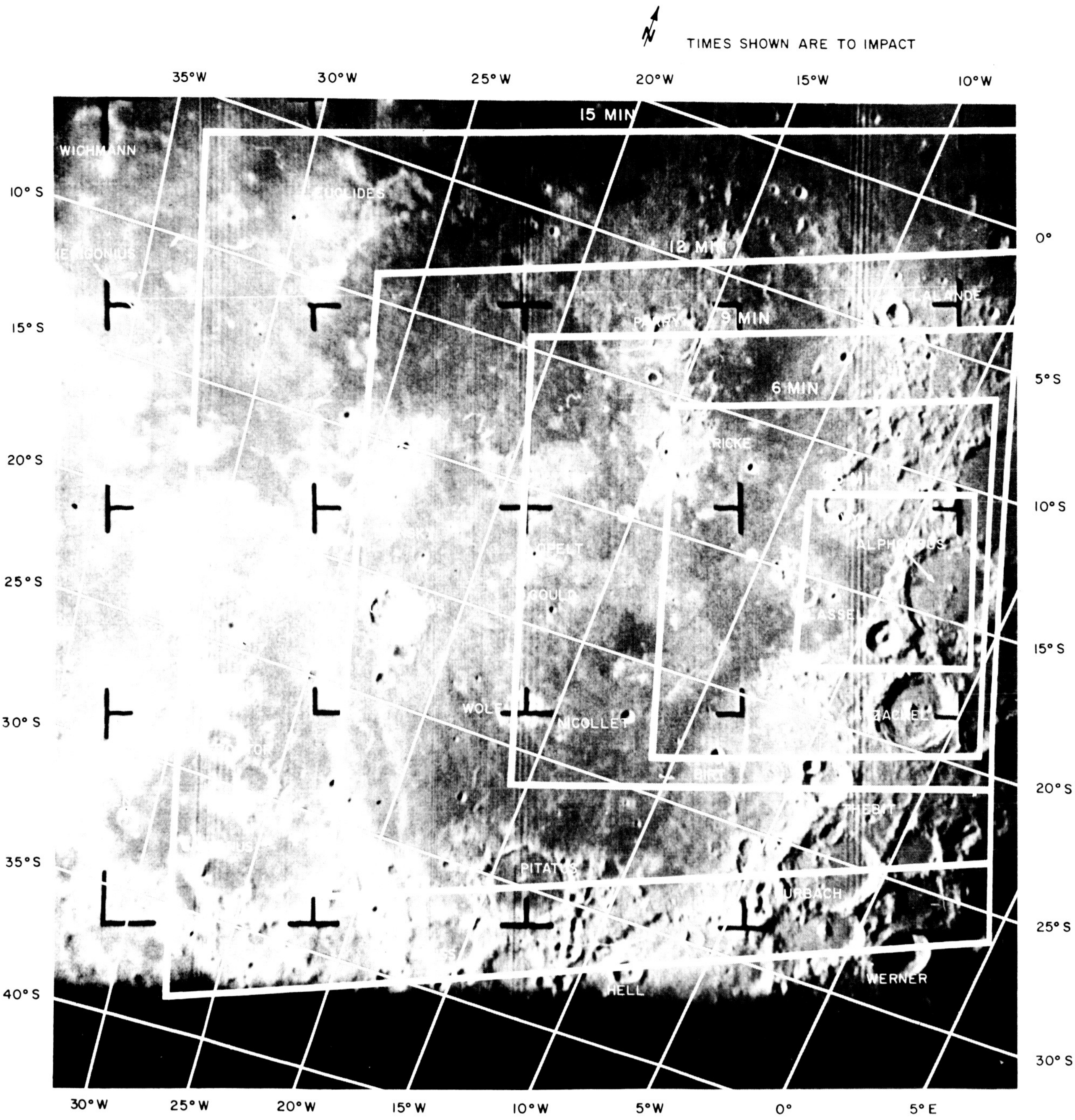


Figure 4-5. Picture nesting achieved by F_a Camera

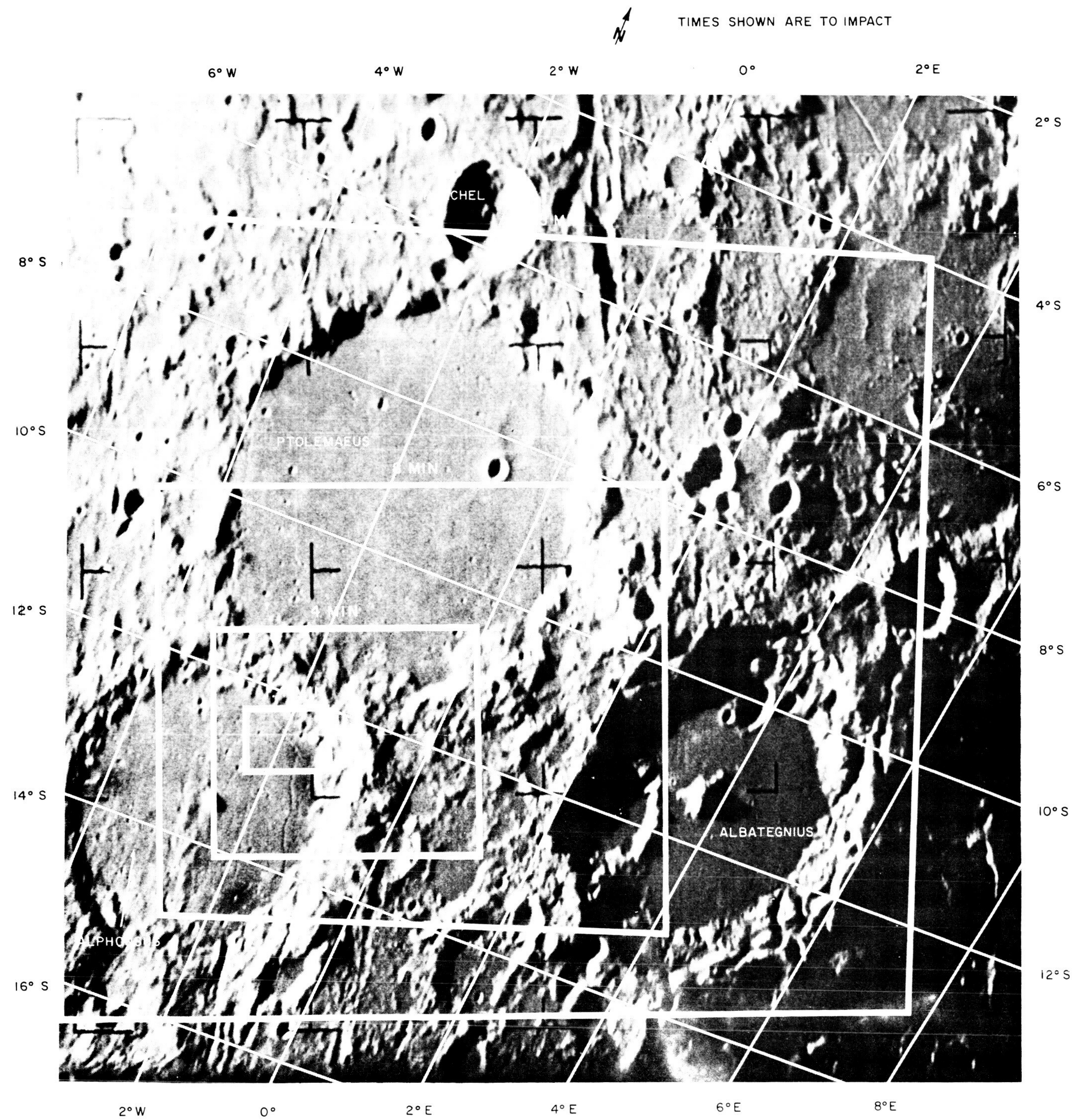


Figure 4-6. Picture nesting achieved by F_b Camera

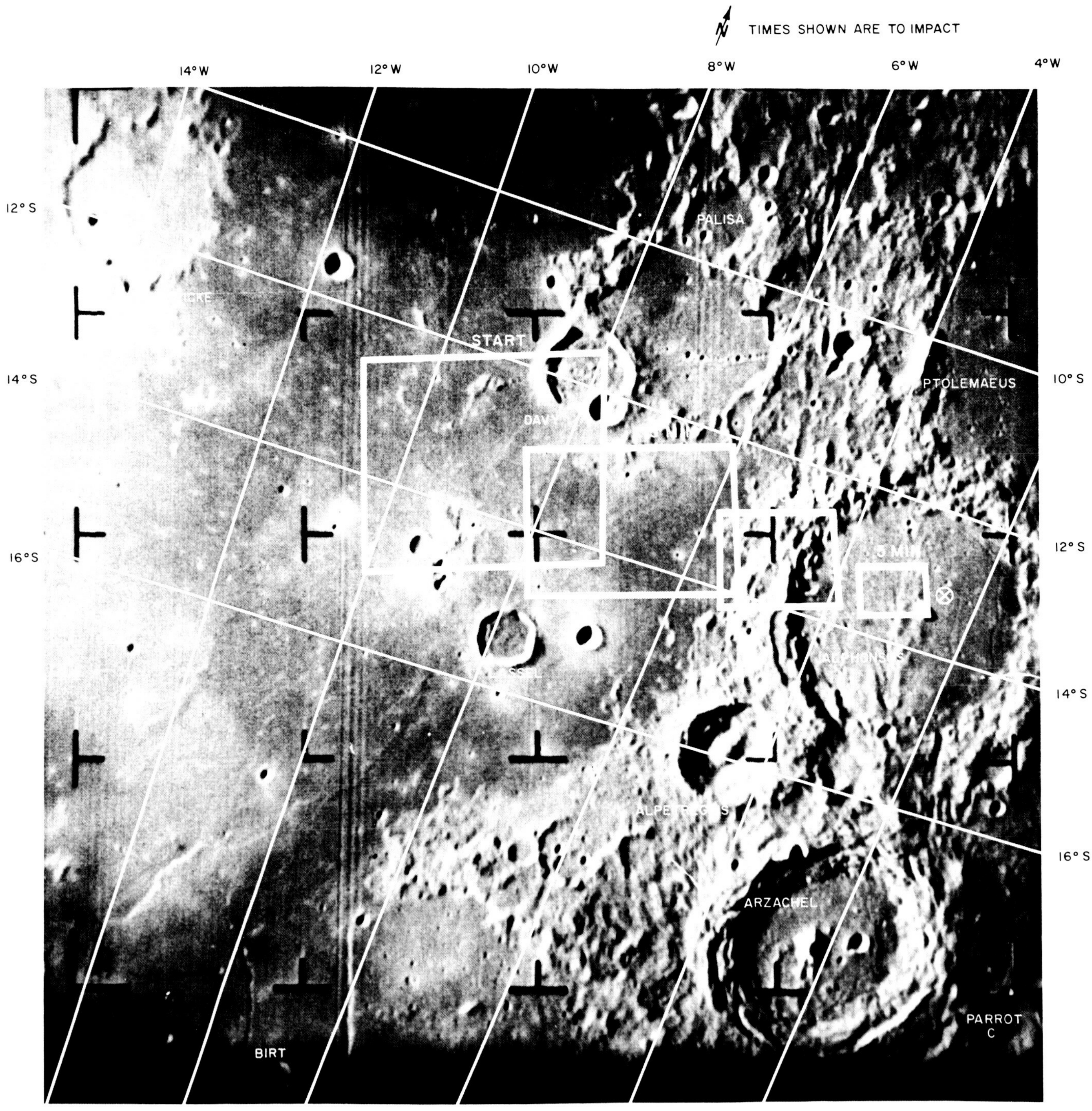


Figure 4-7. Picture nesting achieved by P1 Camera

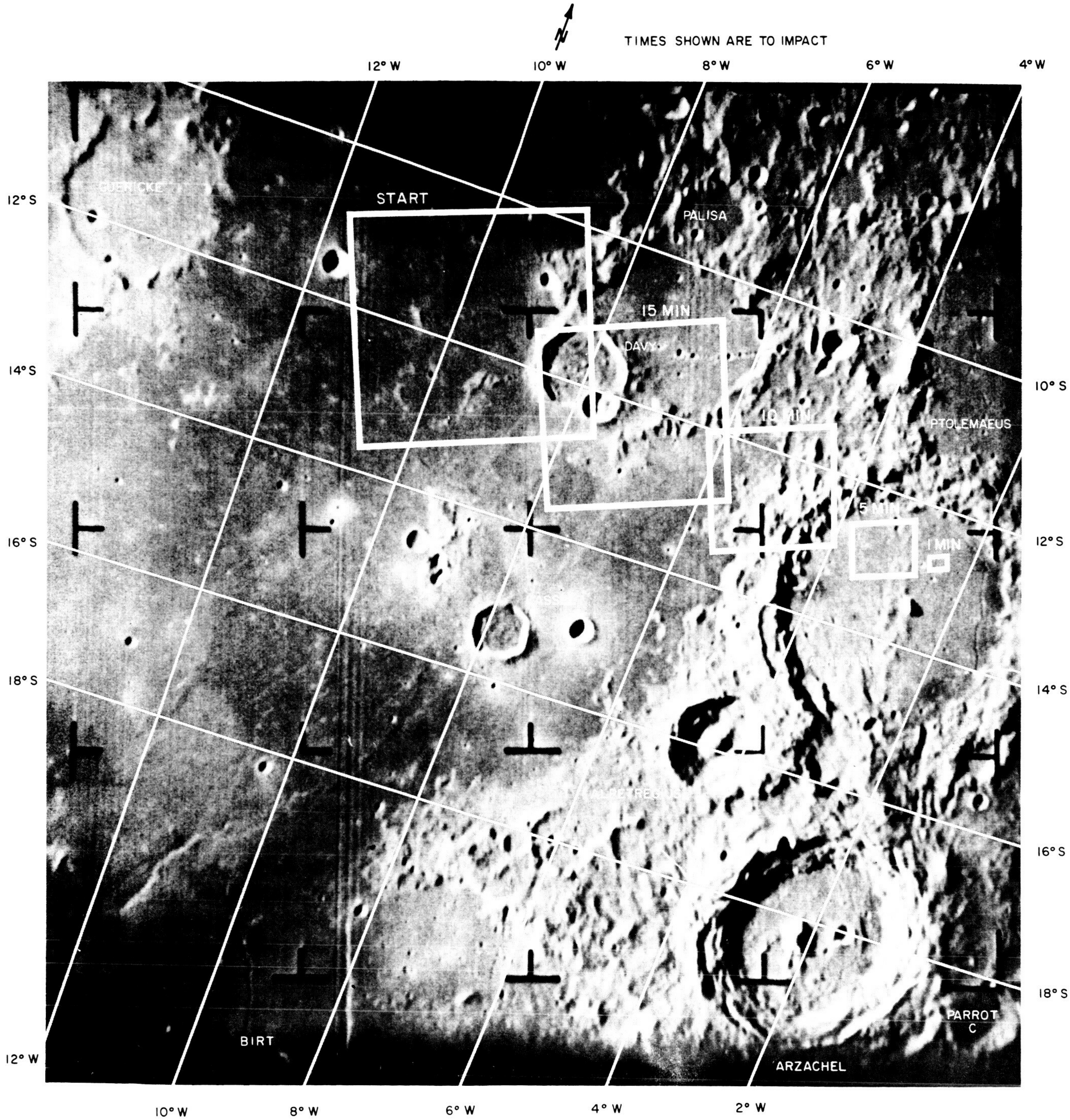


Figure 4-8. Picture nesting achieved by P2 Camera

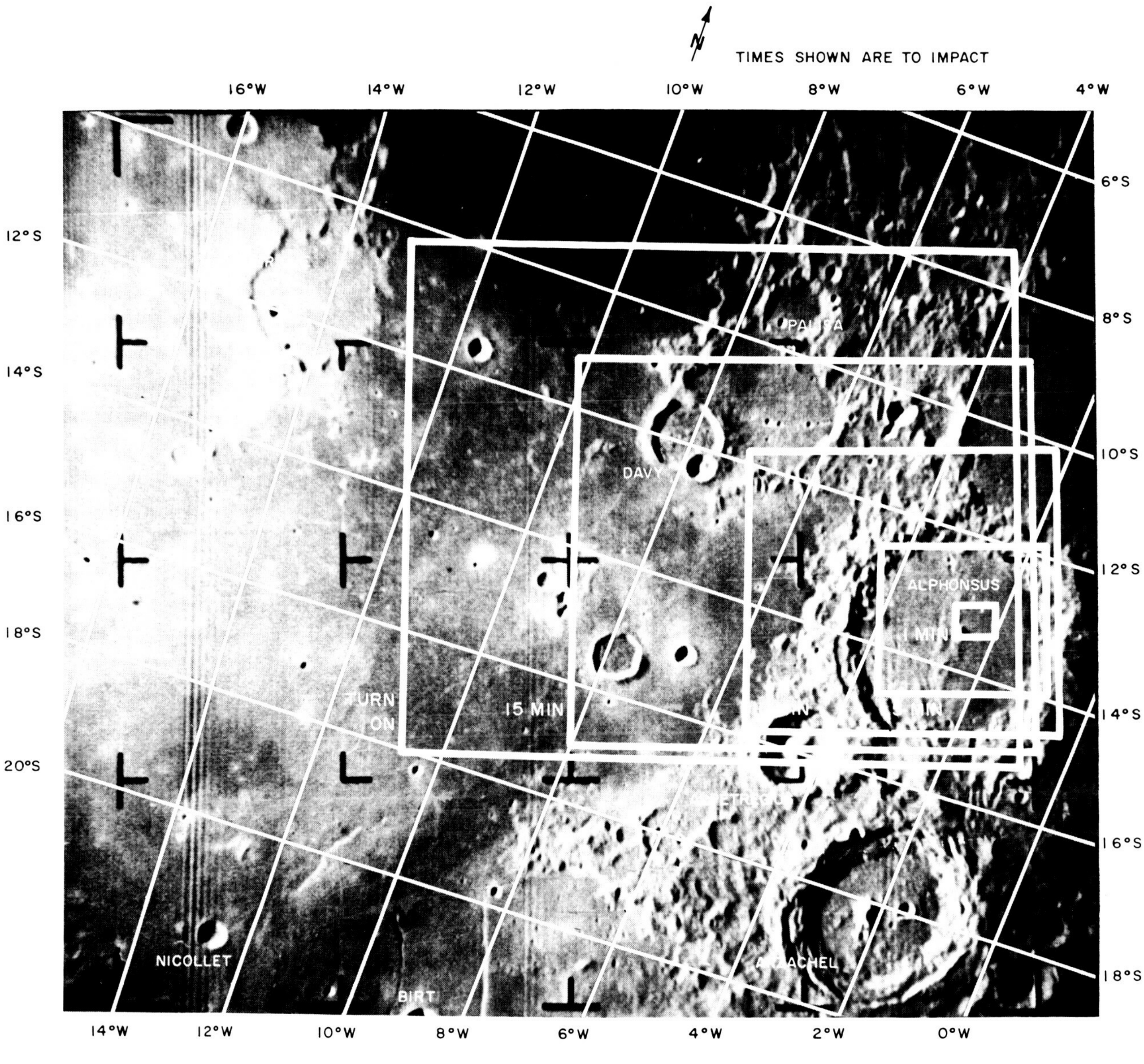


Figure 4-9. Picture nesting achieved by P3 Cameras

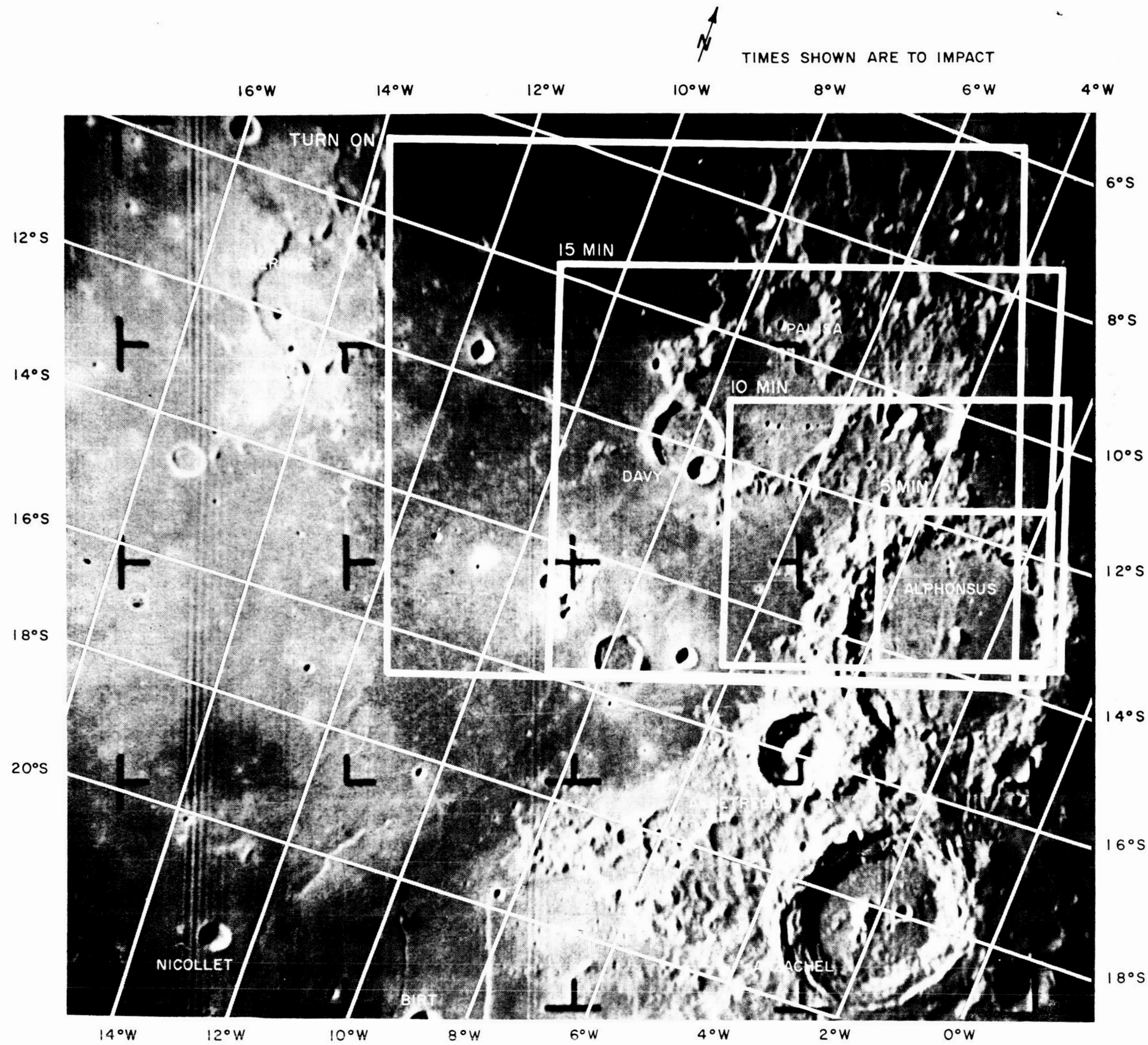


Figure 4-10. Picture nesting achieved by P4 Camera

tests performed on the cameras. During the mission, the camera performance was equally outstanding. Examples of this performance are shown in Figures 4-11 through 4-36. These pictures have A-scope presentations of a single horizontal line of video information, corresponding to the strobe line on the scene picture. Indicated on the A-scope pictures are the approximate amplitudes of the scene illumination. These values were determined from the transfer characteristics obtained during camera calibration. Vertical scale on these pictures is equal to 250 mv/cm.

The excellent transient response of the cameras can be seen in the steep, black-to-white video transitions, as the strobe line passes through a shadowed crater in many of the pictures. The camera gains were set for almost optimum lunar brightness as indicated by the high contrast pictures. At no time did saturation occur.

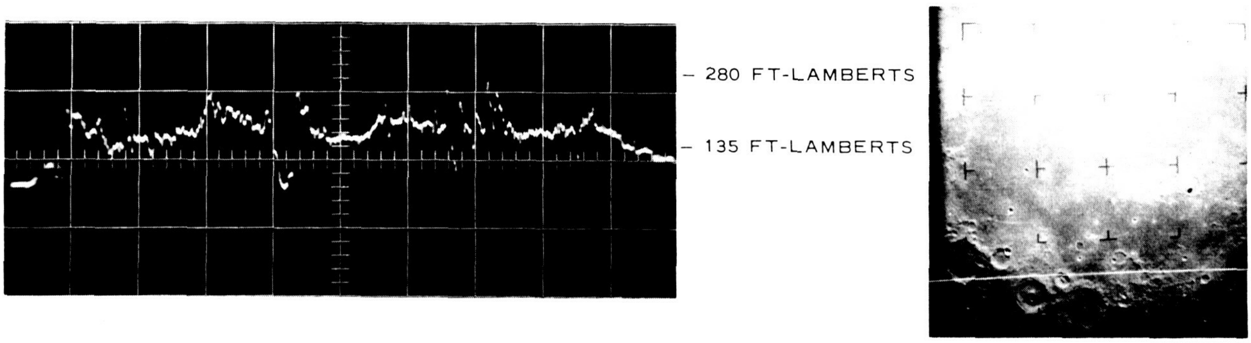


Figure 4-11. Picture taken by the F_a Camera 15 minutes prior to impact

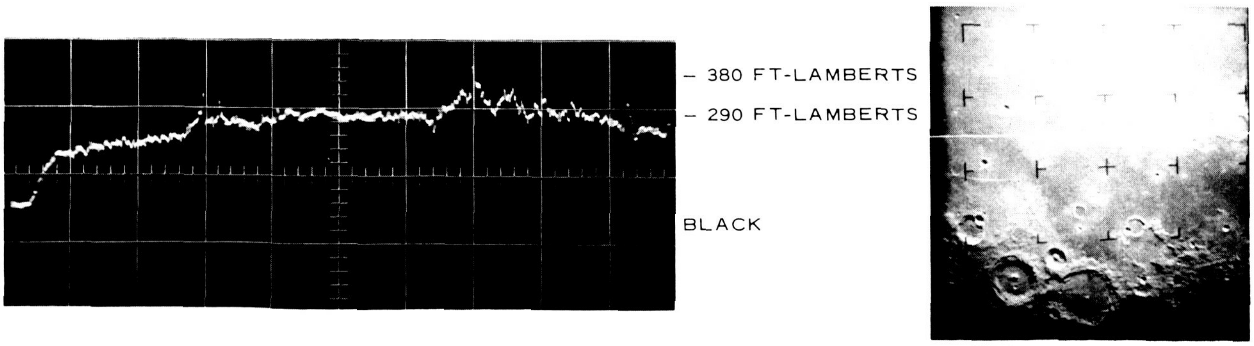


Figure 4-12. Picture taken by the F_a Camera 10 minutes prior to impact

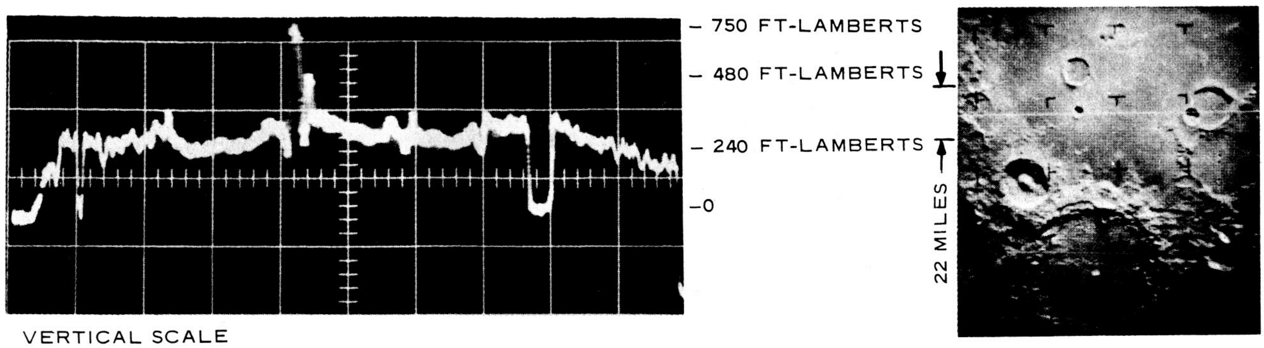


Figure 4-13. Picture taken by the F_a Camera 4 minutes prior to impact

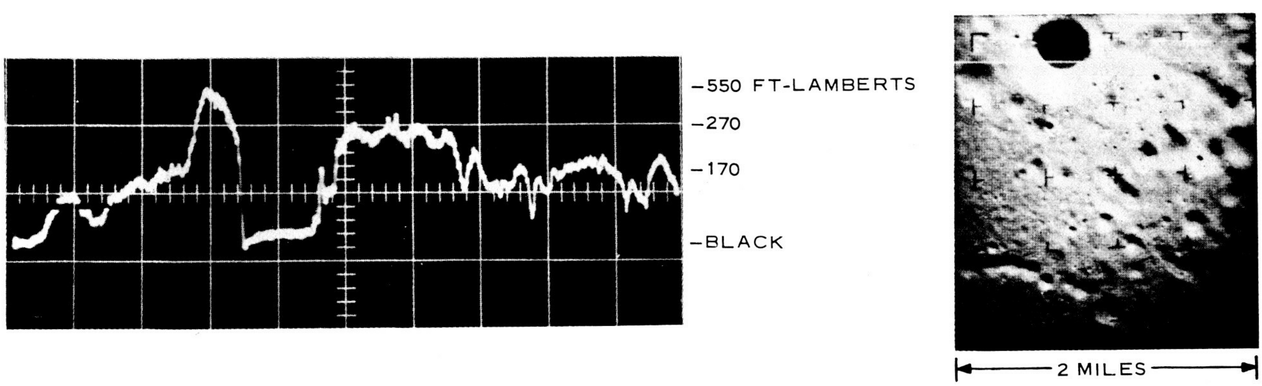


Figure 4-14. Picture taken by the F_a Camera 2.97 seconds prior to impact

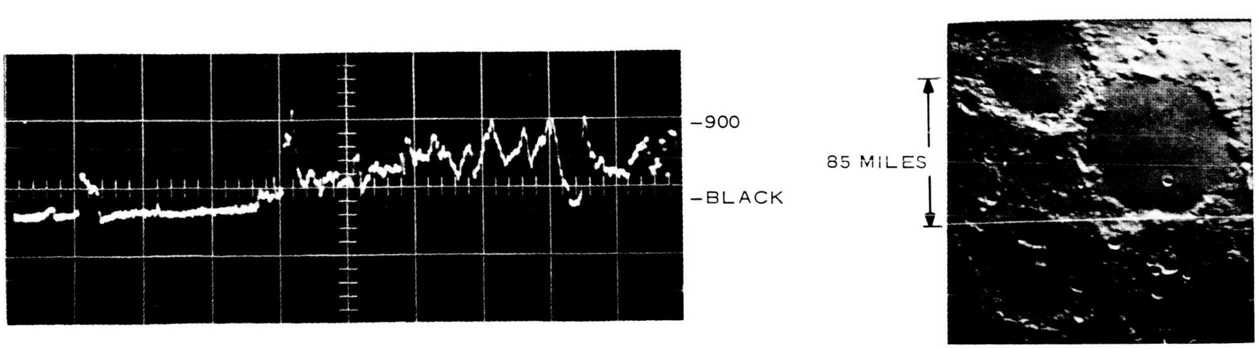


Figure 4-15. Picture taken by the F_b Camera 15 minutes prior to impact

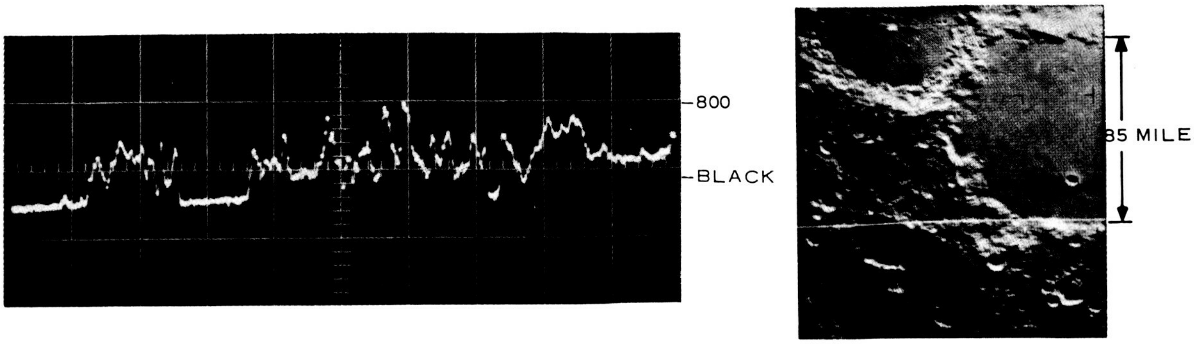


Figure 4-16. Picture taken by the F_b Camera 10 minutes prior to impact

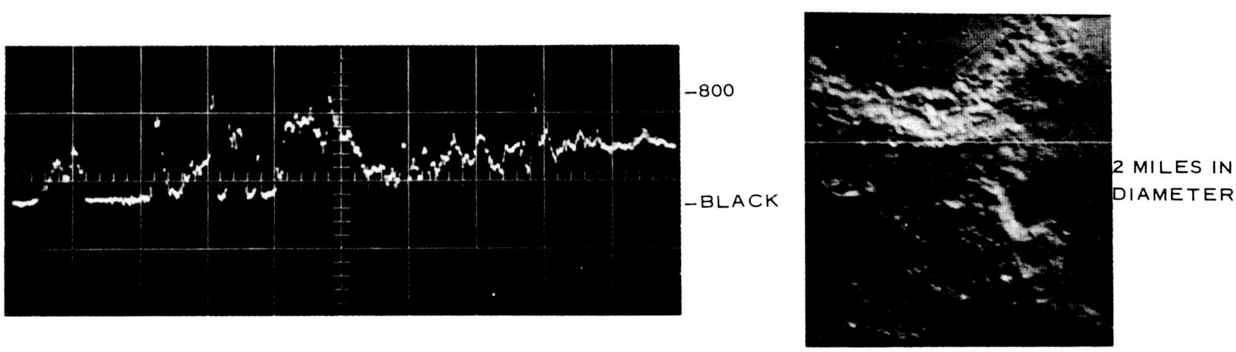


Figure 4-17. Picture taken by the F_b Camera 5 minutes prior to impact

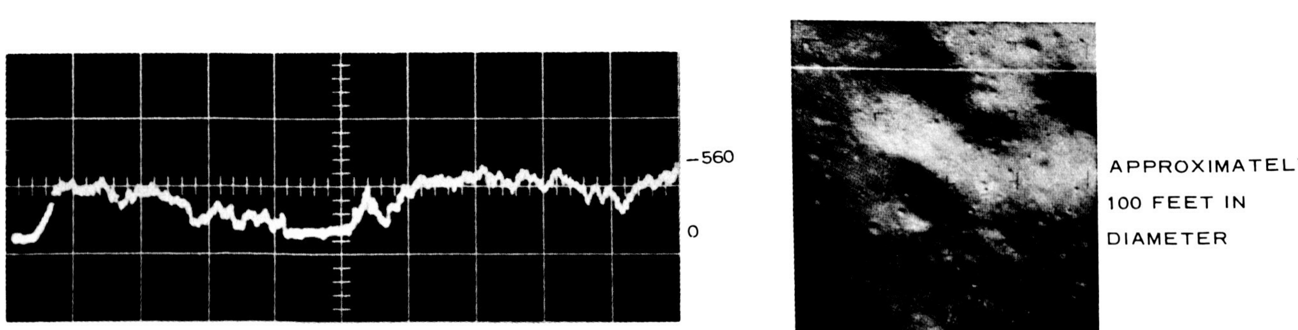


Figure 4-18. Picture taken by the F_b Camera 5.53 seconds prior to impact

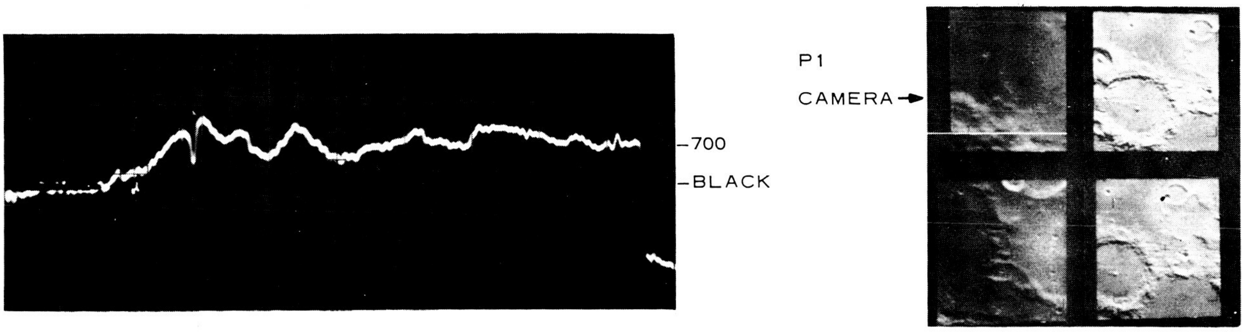


Figure 4-19. Picture taken by the P1 Camera 15 minutes prior to impact

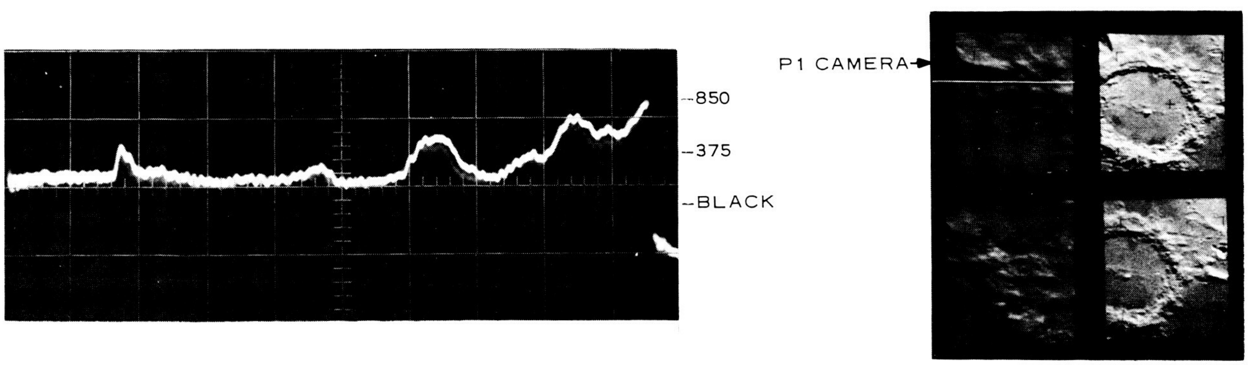


Figure 4-20. Picture taken by the P1 Camera 10 minutes prior to impact

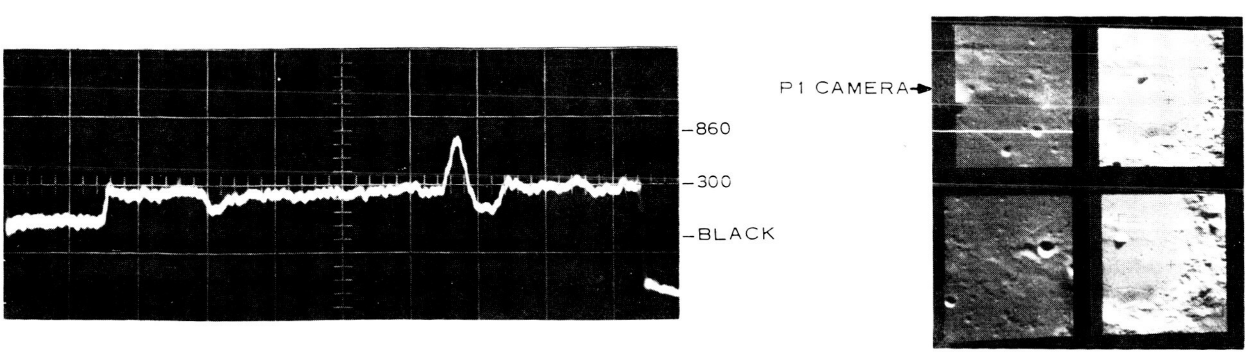


Figure 4-21. Picture taken by the P1 Camera 5 minutes prior to impact

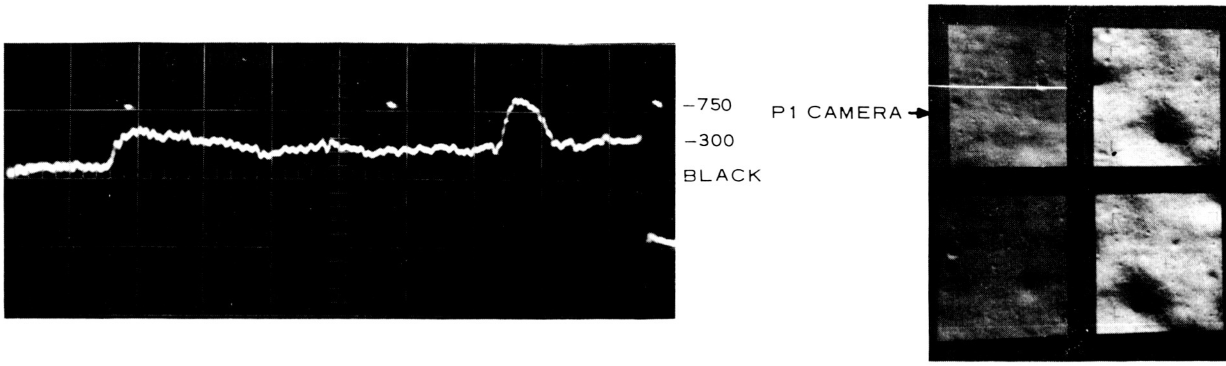


Figure 4-22. Picture taken by the P1 Camera 7 seconds prior to impact

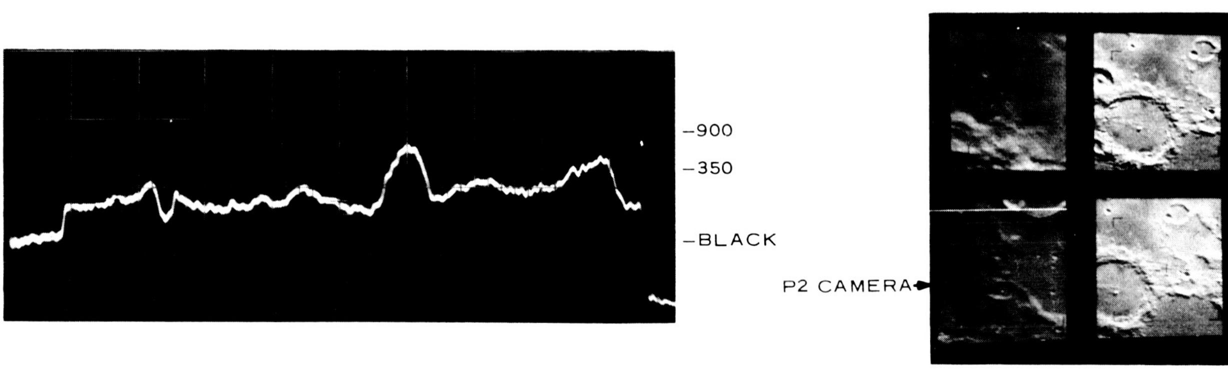


Figure 4-23. Picture taken by the P2 Camera 15 minutes prior to impact

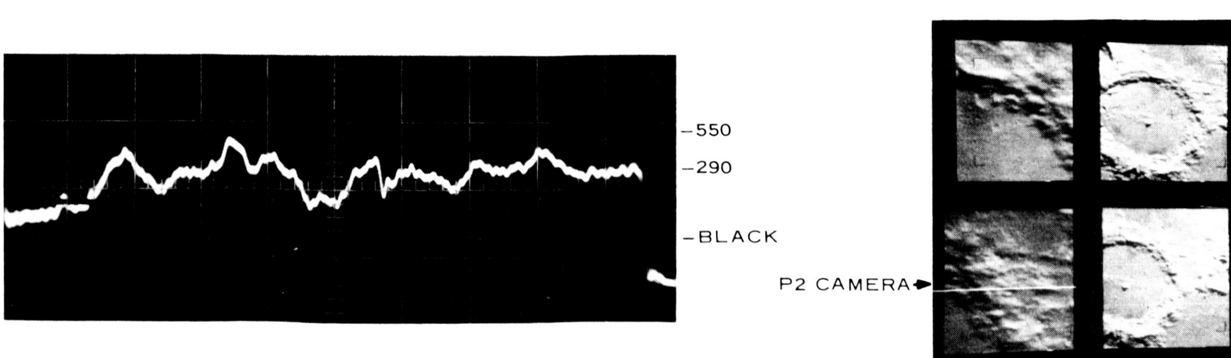


Figure 4-24. Picture taken by the P2 Camera 10 minutes prior to impact

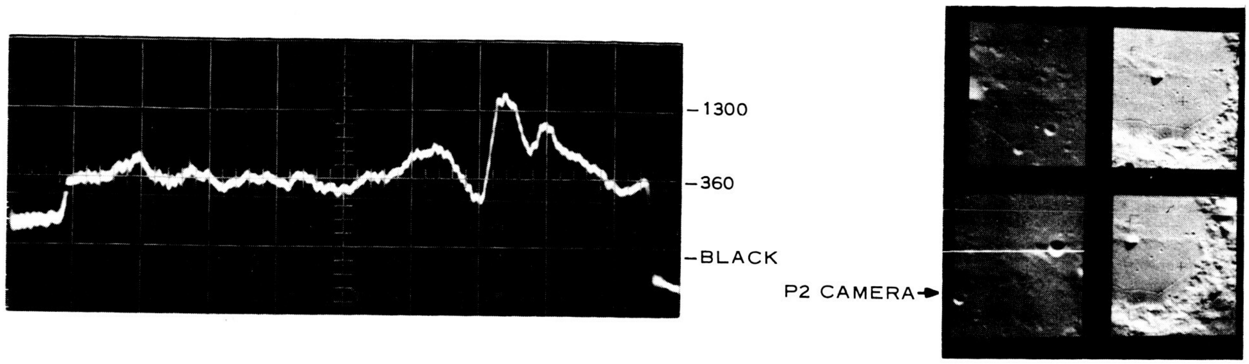


Figure 4-25. Picture taken by the P2 Camera 5 minutes prior to impact

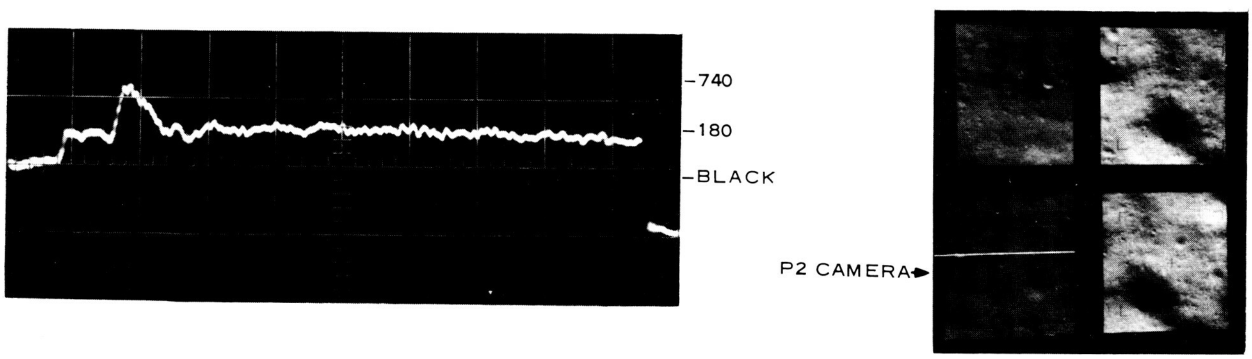


Figure 4-26. Picture taken by the P2 Camera 7 seconds prior to impact

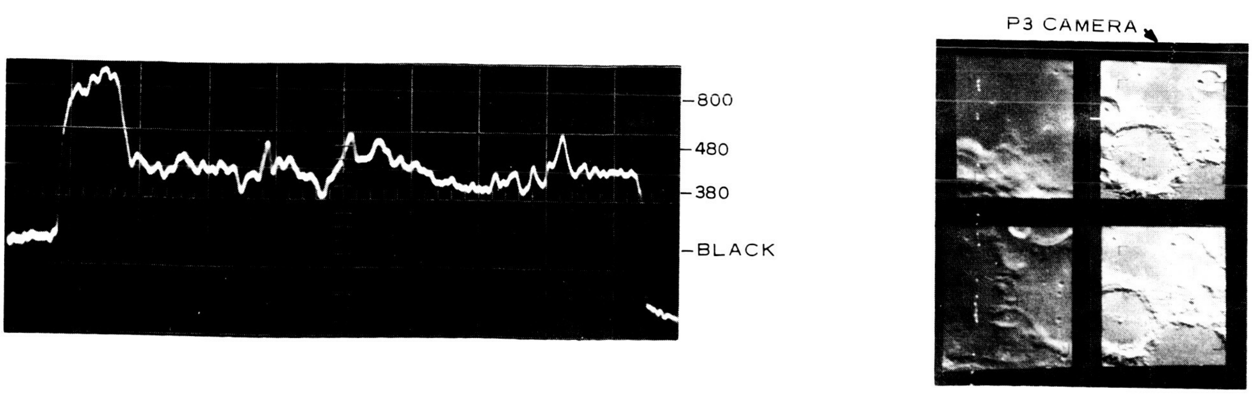


Figure 4-27. Picture taken by the P3 Camera 15 minutes prior to impact

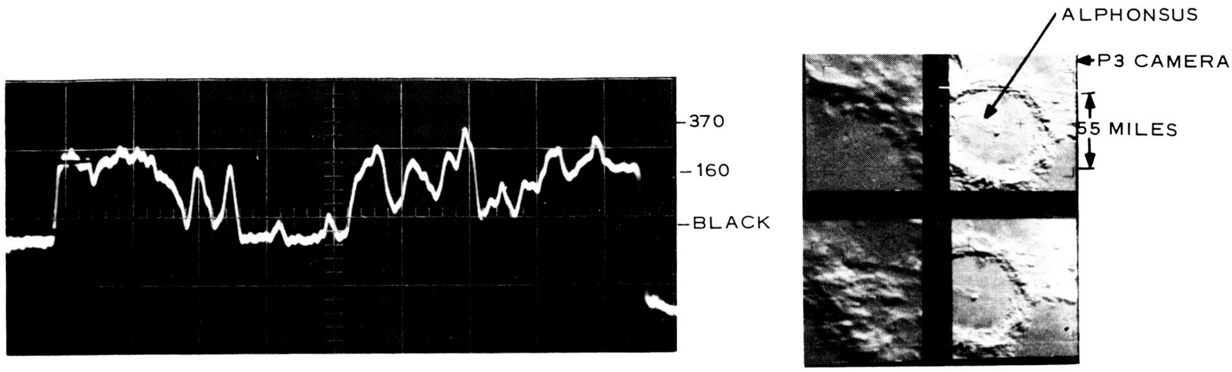


Figure 4-28. Picture taken by the P3 Camera 10 minutes prior to impact

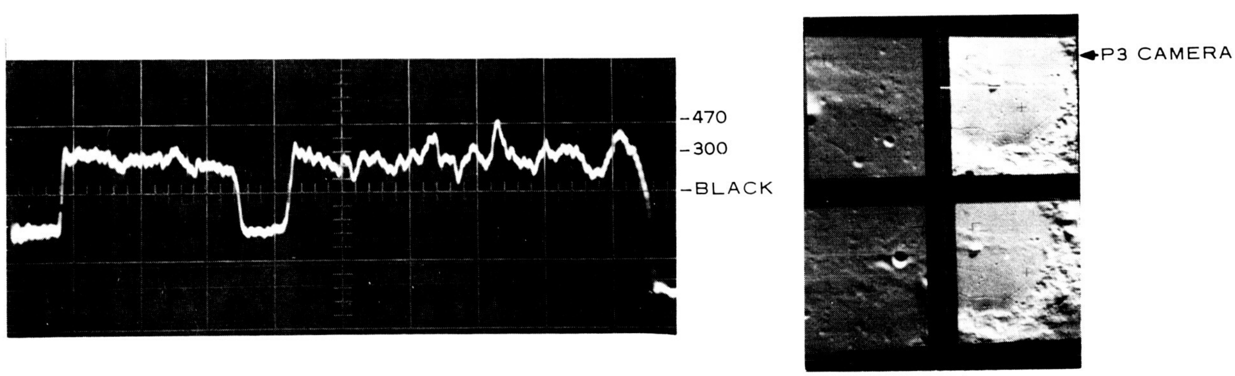


Figure 4-29. Picture taken by the P3 Camera 5 minutes prior to impact

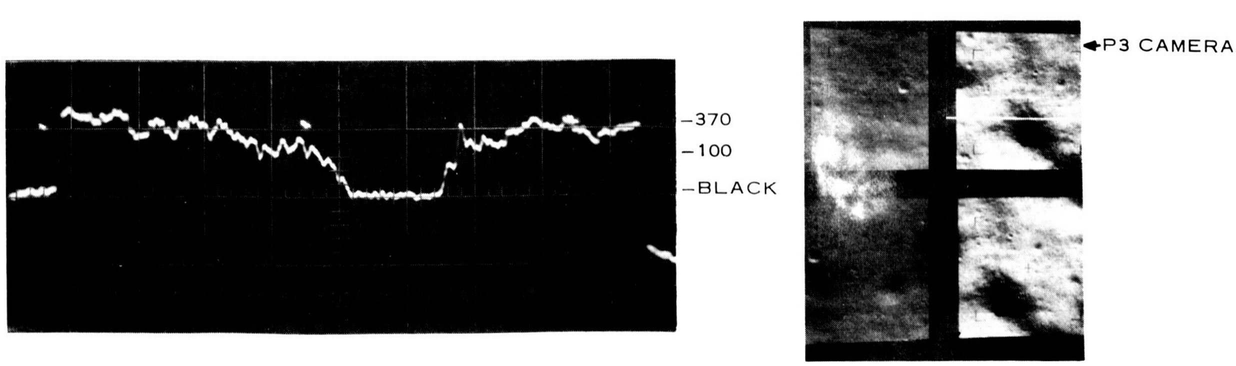


Figure 4-30. Picture taken by the P3 Camera 7 seconds prior to impact

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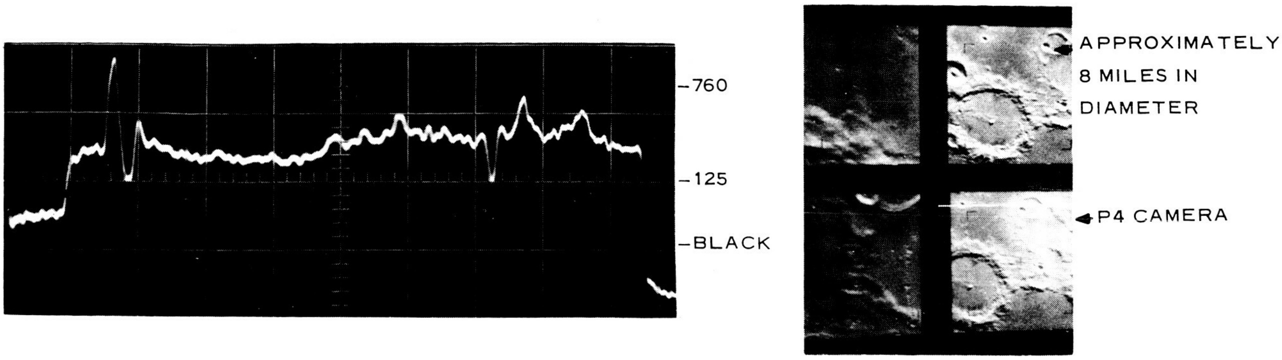

Figure 4-31. Picture taken by the P4 Camera 15 minutes prior to impact

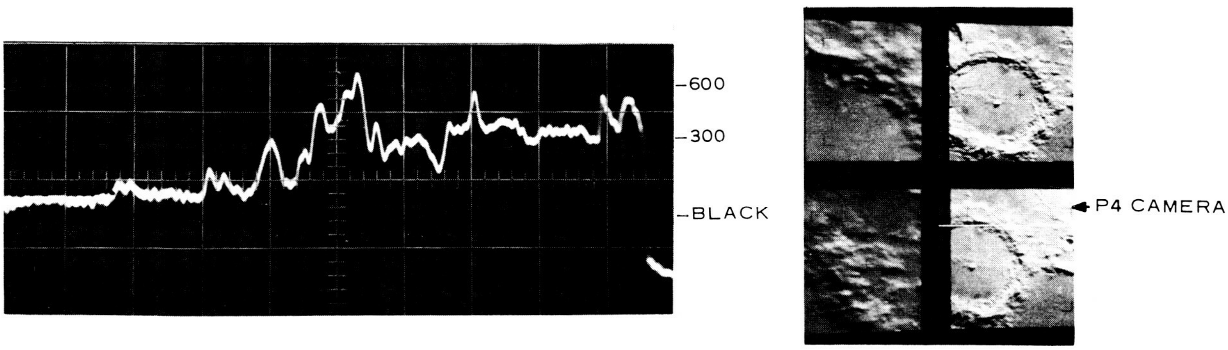

Figure 4-32. Picture taken by the P4 Camera 10 minutes prior to impact

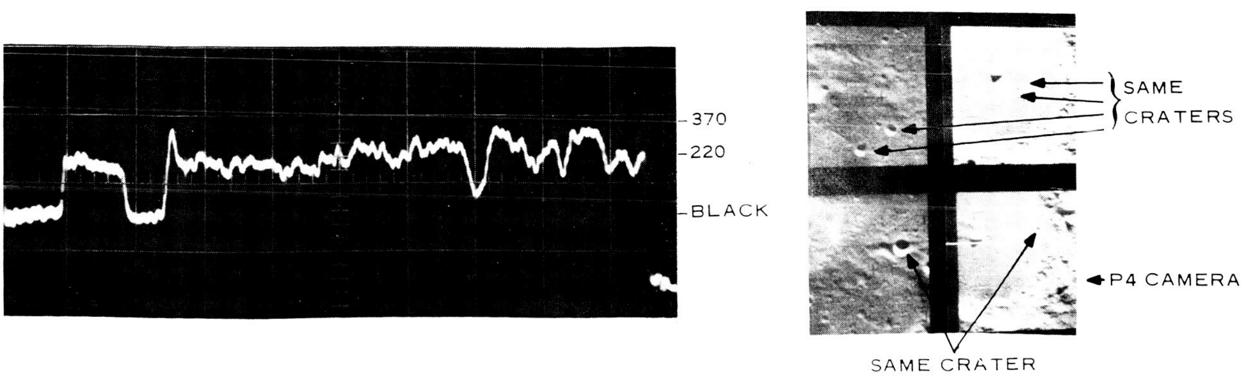

Figure 4-33. Picture taken by the P4 Camera 5 minutes prior to impact

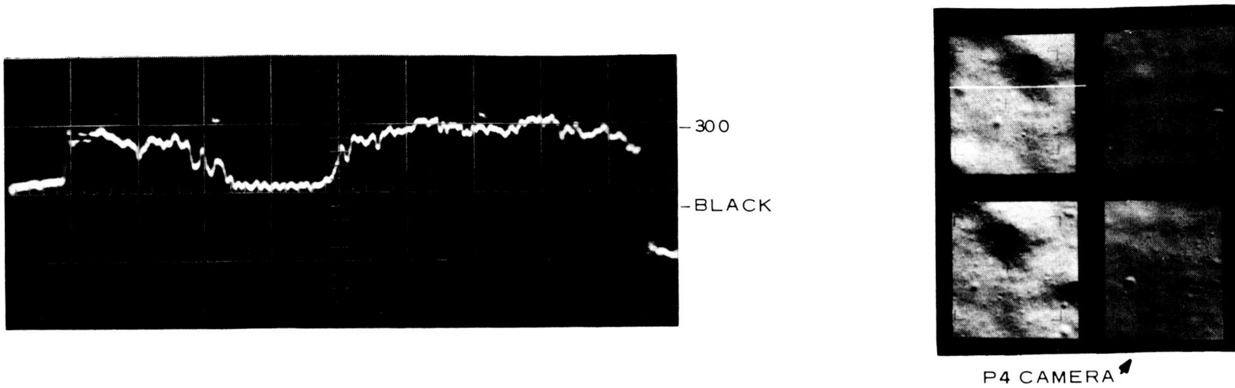

Figure 4-34. Picture taken by the P4 Camera 7 seconds prior to impact

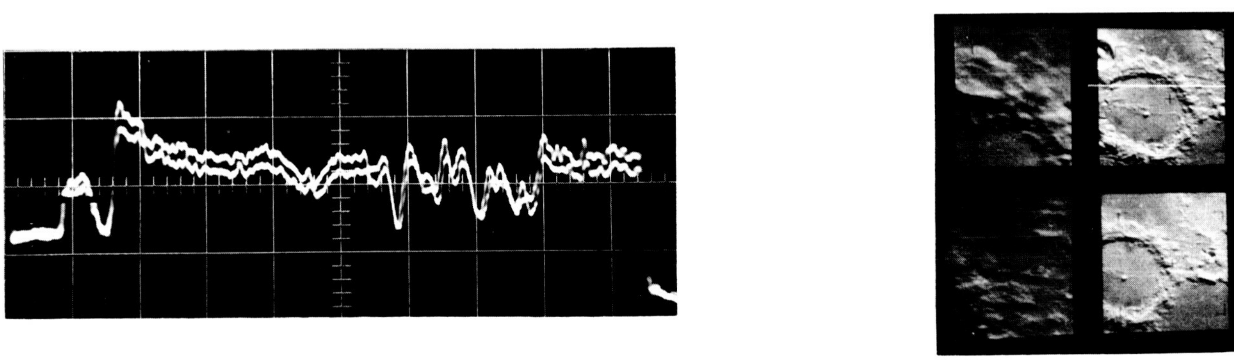

Figure 4-35. Two adjacent lines on a picture taken by the P3 Camera

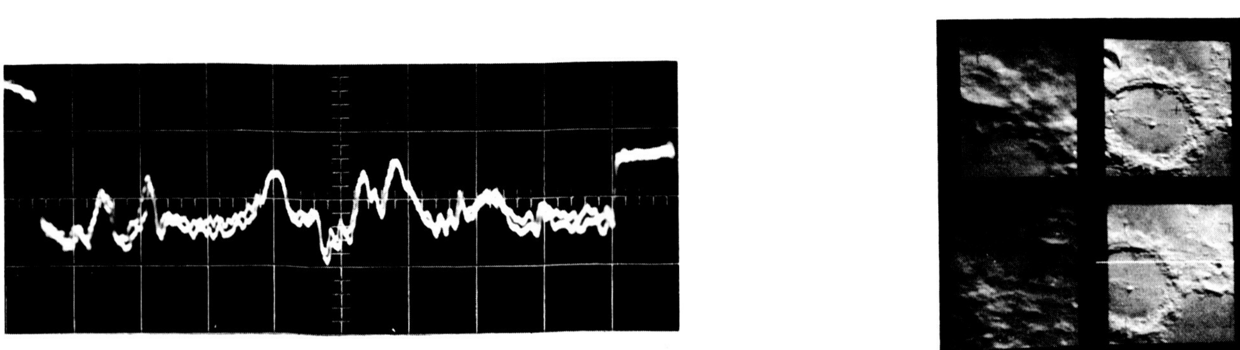

Figure 4-36. Two adjacent lines on a picture taken by the P4 Camera

In some respects, mission performance was better than test performance; certain areas of concern that were present during testing did not occur during the mission or were so infrequent they were considered negligible. These areas were as follows:

- Shutter-Induced Noise Bursts — Noise pulses, which appeared primarily in the P1 and P2 Cameras, originating in an electrostatic discharge from the camera shutter blade;
- Mask Leakage — The P2-Camera mask was not completely opaque, causing a light leakage of approximately 2.5 percent of scene luminance;
- Nuvistor Microphonic Increase — The increase in the nuvistor microphonics occurring in the P1 Camera during the latter test phases;
- Chopper Spikes in the F_a Camera Video Signal — Power-supply chopper spikes, which were traced to the ground of the 1000-volt mesh filter, occurring in the F_a-Camera video signal;
- Vidicon Microphonics — Vidicon microphonics induced in the F_a and P2 Cameras by the P4-Camera shutter;
- First frame of the F_a Camera not exposed — The noise transient occurring at full-power turn-on would occasionally cause the trigger pulse to be applied to the shutter-drive multivibrator when it was in the wrong state.

b. Residual Image

The erase characteristics of the RA-9 Cameras were as follows:

Camera	Percent Erase
P1 and F_b	98
P2, P3, and P4	97
F_a	95.5

Scrutiny of the pictures obtained during the Ranger IX mission revealed no evidence of residual information.

c. Light Transfer Characteristics

Prior to launch, the light transfer characteristics of each RA-9 camera were determined. This was accomplished by measuring the response of the camera to a narrow white bar of known luminance. The response was measured at the center of the scanned format. The gains of the F_b, P1, and P2 Cameras were adjusted for a peak scene luminance of 1500 foot-lamberts, and the gains of the F_a, P3, and P4 Cameras were adjusted for a peak scene luminance of 650 foot-lamberts. The luminance of the calibration source was varied and the video excursions at the output of the distribution amplifier were recorded. The data recorded were plotted for each camera and resulted in the light transfer curves presented in Figures 4-37 and 4-38.

d. Performance Improvements

Some significant improvements in Flight Model III-4 performance over previous flight models were as follows:

- 15-kilocycle cross talk — In previous subsystems, 15-kc crosstalk with amplitudes between 50 and 80 millivolts were encountered in Flight Model III-4, crosstalk was less than 10 millivolts in amplitude. This was achieved through experience gained in the grounding and tie-down of the previous flight models;

- Mesh Noise — Five of the six vidicons of Flight Model III-4 were equipped with the 1500-line mesh electrode. Modulation of the read beam by the mesh was almost negligible. An improved signal-noise ratio was thus realized. The excellent signal-to-noise ratios for the Flight Model III-4 cameras were:

Camera	Signal-to-noise ratio (db)
P1	36
P2	30.5
P3 and F_a	35.5
P4	35.6
F_b	34

- Reduction of low-frequency video amplifier noise — Low-frequency noise sources, such as zener diodes, were optimized for minimum noise output.

Although performance of the TV Subsystem during the RA-9 mission was excellent, the elimination of the following characteristics on Flight Model III-4 would help achieve an optimum system:

- Differences in shutter exposure times — The P3 and P4 Cameras had timing differences in the in and out strokes of the shutter. During camera

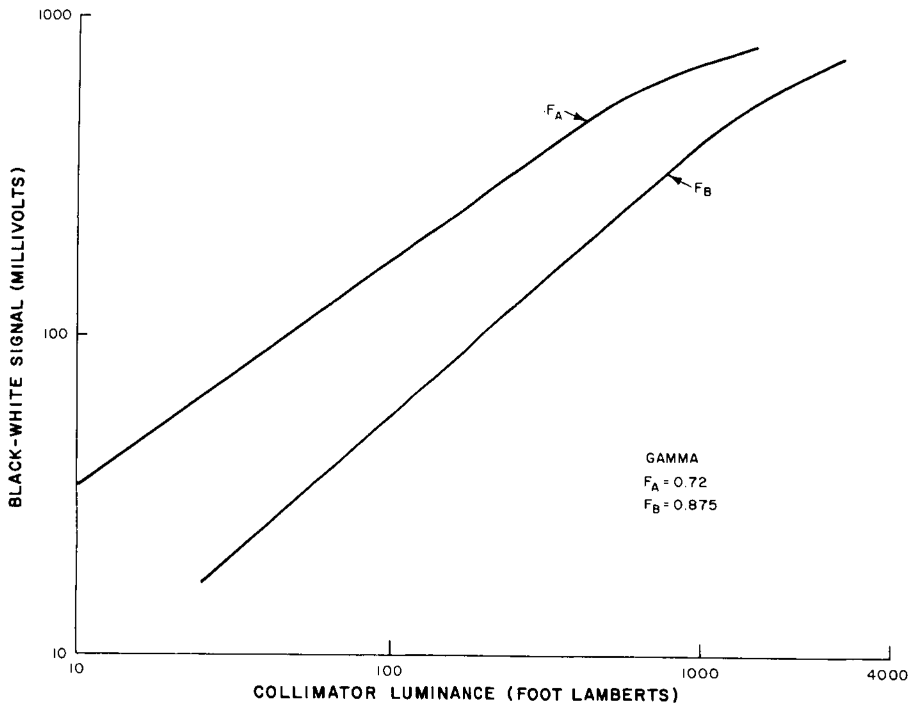

Figure 4-37. Light transfer characteristic curves for the RA-9 full-scan cameras

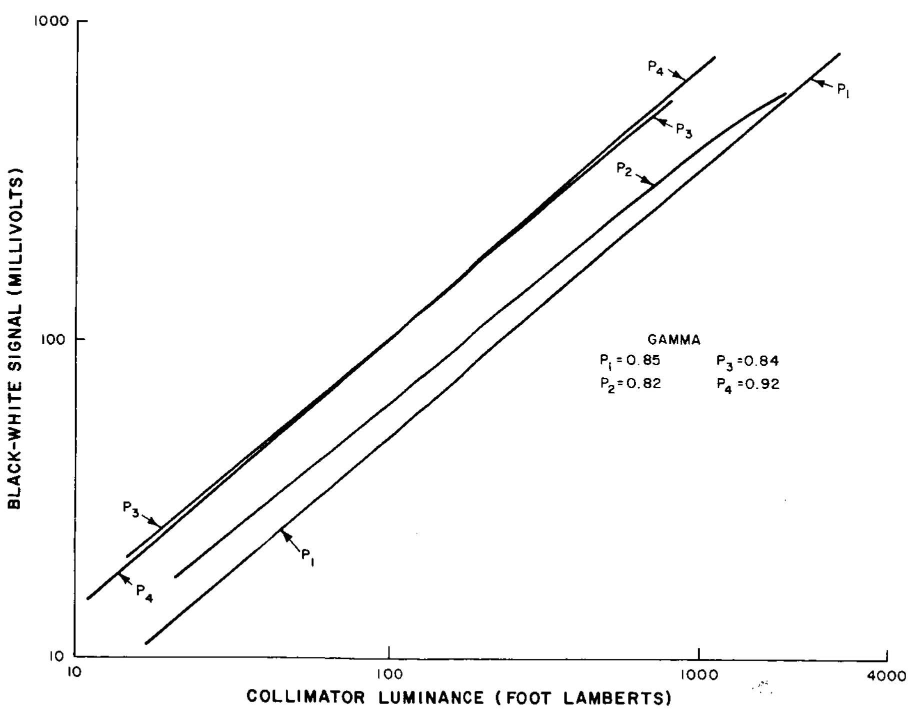

Figure 4-38. Light transfer characteristic curves for the RA-9 partial-scan cameras

calibration, the difference in amplitude of the video output during the in and out shutter strokes was found to be approximately 80 millivolts. The difference in exposure times during the mission caused the following amplitude variation per shutter stroke: the P3 Camera had approximately a 60-mv difference, and the P4 Camera had approximately a 50-mv difference.

- Shading — The non-uniform electrical charge distribution over the target area (shading) has been a persistent camera problem which recently has been corrected by modifying the vidicon construction and optimizing the location of the vidicon in relation to the yoke. Ranger IX camera shading characteristics were:

Camera	White field vertical shading (mv, p-p)
P1	145
P2	160
P3	120
P4	80
F_a	560
F_b	440

C. Thermal Control Group

The thermal configuration of the RA-9 TV Subsystem is shown in Figure 4-39. Primary temperature-control surfaces are:

- Thermal shroud (polished aluminum vehicle skin);
- Thermal fins; and
- Thermal shields (insulators).

The construction of the shroud and fin assembly is such that solar energy striking the Spacecraft parallel to its axis illuminates only the top surfaces of the fins, i.e., no direct sunlight is incident upon the thermal shroud. The flow of thermal energy with this condition is as follows:

- Sunlight strikes the fin surface at a normal angle of incidence and a portion is absorbed. The remainder is reflected to space and other parts of the Spacecraft.

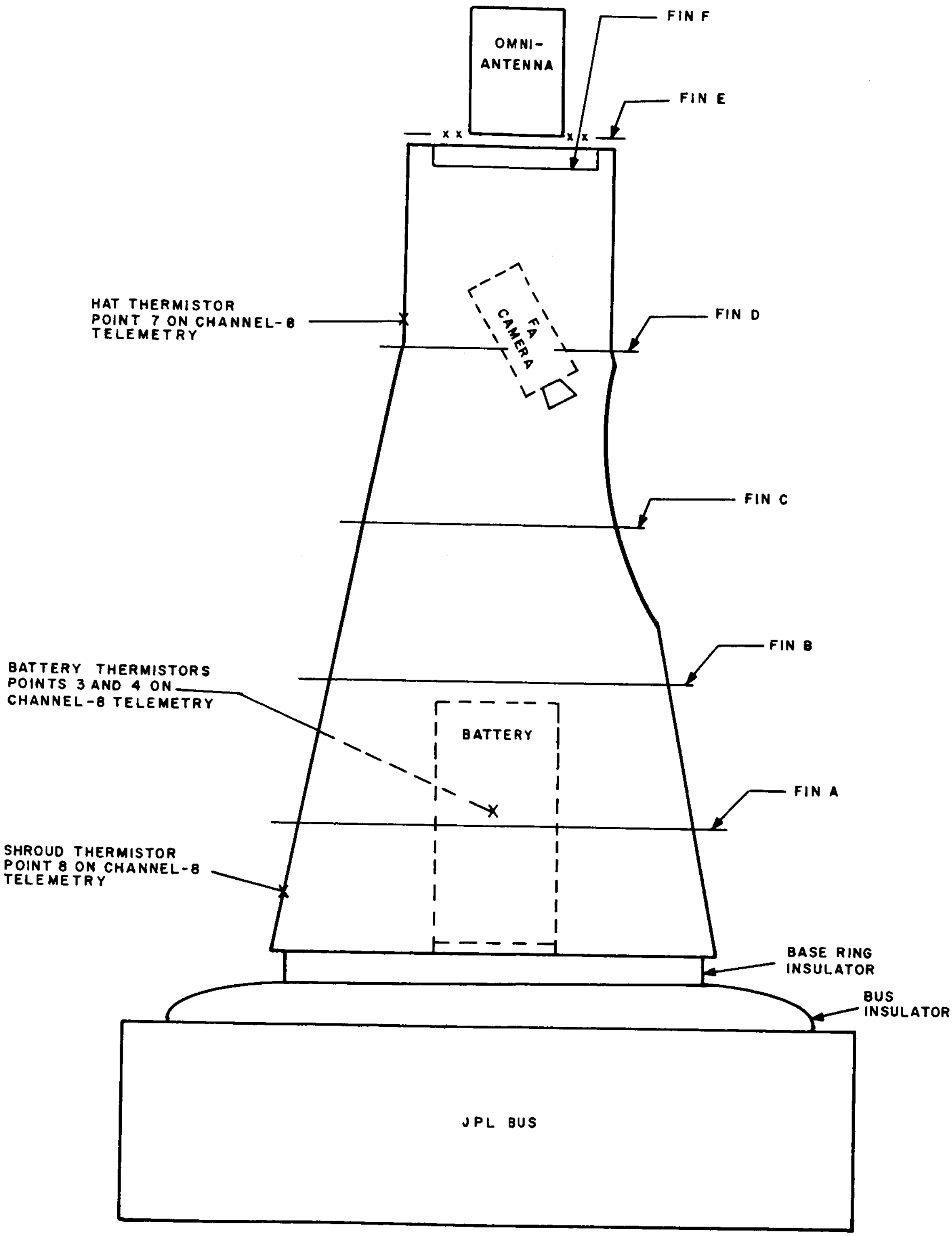

Figure 4-39. Thermal configuration of the TV Subsystem

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- Part of the energy absorbed by the fin is radiated from the front and rear surfaces of the fin; the remainder flows into the thermal shroud.

- The energy flowing into the thermal shrouds from the fins is radiated from the shroud surface (polished aluminum), establishing a temperature field on the shroud surface.

- The temperature field established on the shroud is essentially isothermal; since the shroud envelopes all electronic equipment, the equipment will come to this same temperature at steady-state conditions. During full-power operation of the equipment, the temperatures of individual components are maintained below maximum temperature limits due to the "heat-sinking" properties of the Spacecraft.

1. Flight Temperature Predictions

To predict the flight temperatures for RA-9, the ratio factors determined from the analysis of the RA-6 flight data were used. The determination of these factors is covered in Appendix E of the "Flight Evaluation Report for Flight Model III-2", issued October 30, 1964. The equations used in the temperature calculations were derived from the "least squares fit of Spacecraft temperatures" described in Appendix D of the same report.

The energy input to the TV Subsystem was calculated by applying the ratio factors to the results of the calculations for the direct solar energy input, which was incident upon the top surfaces of the temperature-control fins. The ratio factors empirically account for reflections and deviations from predicted inputs as experienced in the RA-6 flight.

The ratio factor ψ is applicable to the inputs of fins A, B, C, and D; the ratio factor ϕ is applicable to the inputs of fins E and F. The direct solar input to fin A is given by:

$$Q_A' = S\, A_A \alpha_A$$

where

Q_A' = direct solar input to fin A

S = solar constant

A_A = area of fin A

α_A = absorptivity of fin A

With the ratio factor applied, the input to the fins is given by:

$$\text{Fin A} = Q_A = Q_A{}'\psi$$

$$\text{Fin B} = Q_B = Q_B{}'\psi$$

$$\text{Fin C} = Q_C = Q_C{}'\psi$$

$$\text{Fin D} = Q_D = Q_D{}'\psi$$

$$\text{Fin E} = Q_E = Q_E{}'\phi$$

$$\text{Fin F} = Q_F = Q_F{}'\phi.$$

From previous determinations, it was found that $\psi = 1.37$ and $\phi = 0.85$. Therefore, using the RCA absorptivity (α) measurements, the input to fin A is given by:

$$Q_A = SA_A\alpha_A\psi = (0.905)\ (58.5)\ (0.48)\ (1.37) = 34.8 \text{ watts}$$

The inputs to the other fins are:

$$Q_B = 47.2 \text{ watts}$$

$$Q_C = 56.8 \text{ watts}$$

$$Q_D = 62.0 \text{ watts}$$

$$Q_E = 6.9 \text{ watts}$$

$$Q_F = 28.9 \text{ watts.}$$

The cruise-mode telemetry equilibrium temperatures are given by the following equations:

$$\sigma T^4{}_{HAT} = (1.0934)X + (0.7130)Y + (0.0590)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4{}_{VID} = (0.9065)X + (0.6608)Y + (0.1941)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4{}_{SHR} = (1.1656)X - (0.2603)Y - (0.0921)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4{}_{BAT} = (1.0892)X - (0.0762)Y + (0.0559)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4{}_{CAM} = (1.0837)X - (0.1281)Y + (0.1457)Z \times 10^{-3} \text{ watts/in}^2$$

where

HAT = Thermal shroud hat, -Y side

VID = F_a Camera lens housing

SHR = Thermal shroud, -Y side, below fin A

BAT = Battery, Internal, P-Channel

CAM = Camera Electronics, -Y side

σ = Stefan-Boltzmann radiation constant

T = Temperature, °K

X = $Q_A + Q_B + Q_C + Q_D + Q_E + Q_F = 236.6$ watts

Y = $-2Q_A - Q_B + Q_D + 2Q_E + 2Q_F = 16.8$ watts

Z = $-2Q_A + Q_B + 2Q_C + Q_D - 2Q_E - 2Q_F = 81.6$ watts.

Substituting these X, Y, and Z values in the equilibrium temperature equations, the results are:

$\sigma T^4_{HAT} = 0.276$ T = 22°C = 72°F

$\sigma T^4_{VID} = 0.241$ T = 12°C = 54°F

$\sigma T^4_{SHR} = 0.264$ T = 19°C = 66°F

$\sigma T^4_{BAT} = 0.261$ T = 18°C = 64°F

$\sigma T^4_{CAM} = 0.266$ T = 19°C = 66°F

Using the JPL/STL measured absorptivities (α) in the same equations, the results are:

$\sigma T^4_{HAT} = 0.287$ T = 25°C = 77°F

$\sigma T^4_{VID} = 0.251$ T = 15°C = 59°F

$\sigma T^4_{SHR} = 0.275$ T = 22°C = 72°F

$\sigma T^4_{BAT} = 0.271$ T = 22°C = 72°F

$\sigma T^4_{CAM} = 0.277$ T = 22°C = 72°F

Based on the results of the RA-7 flight data, the flight temperatures, except for the camera electronics, followed the values that were obtained by using the JPL measurements. The RA-7 flight results show that the camera-electronics temperature was just below the value calculated using the RCA absorptivity measurements. The cruise-mode temperatures predicted for the RA-7 flight are listed in Table 4-5. The equations used in calculating the remaining predicted temperatures are:

$$(\sigma T^4)_{PAF} = (1.709)X - (0.0177)Y + (0.1532)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{PAP} = (1.0926)X - (0.0429)Y + (0.0888)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{CBR} = (1.010)X + (0.7780)Y + (0.2004)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{VREG} = (1.013)X + (0.0862)Y + (0.1228)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{TPS} = (1.0778)X - (0.0127)Y + (0.004)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{CON} = (1.1388)X + (1.6419)Y + (0.1642)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{SHRD} = (1.1013)X - (0.1818)Y + (0.0471)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{SHRBC} = (1.1174)X - (0.0427)Y + (0.2437)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK3} = (1.1583)X - (0.2385)Y + (0.0967)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK4} = (1.153)X - (0.1721)Y - (0.0808)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK5} = (1.0865)X - (0.0157)Y - (0.0663)Z \times 10^{-3} \text{ watts/in}^2$$

where

PAF = Power Amplifier, -X side, cavity end, F-Channel

PAP = Power Amplifier, +X side, cavity end, P-Channel

CBR = Camera Mounting Bracket

VREG = High-Current Voltage Regulator, +Y side, P-Channel

TPS = Transmitter Power Supply, +X side, P-Channel

CON = Temperature Control Plate, center (fin F)

SHRD = Thermal Shroud, +Y side, below fin A

SHRBC = Thermal Shroud, -Y side, between fins B and C

DK 3 = Deck No. 3, -Y side

DK 4 = Deck No. 4, -Y side

DK 5 = Deck No. 5, -Y side.

TABLE 4–5
CRUISE-MODE STABILIZED TEMPERATURE PREDICTIONS FOR FLIGHT MODEL III-4

Location on TV Subsystem	Calculated Using RCA Measured α Temperature		Calculated Using JPL/STL Measured α Temperature		Actual Flight Telemetry, RA-9 Temperature	
	°C	°F	°C	°F	°C	°F
Thermal Shroud, Hat, -Y side	22	72	25	77	26	79
Camera Lens Housing	12	54	15	59	17	63
Thermal Shroud, -Y side, Below Fin A	19	66	22	72	25	76
Battery, Internal, Ch. P.	18	64	21	70	26	78
Camera Electronics, -Y side	19	66	22	72	21	70
Power Amplifier, -X side, Cavity End, Ch. F	19	66	22	72		
Power Amplifier, +X side, Cavity End, Ch. P	19	66	22	72		
Camera Mounting Bracket	20	68	22	72		
High-Current Voltage Regulator, +Y side, Ch. P	15	59	18	64		
Transmitter Power Supply, +X side, Ch. P	16	61	19	66		
Temperature Control Plate (Fin F)	30	86	32	90		
Thermal Shroud, +Y side, Below Fin A	18	64	21	70		
Thermal Shroud, -Y side, Between Fins B & C	24	75	27	81		
Deck No. 3, -Y side	22	72	25	77		
Deck No. 4, -Y side	18	64	21	70		
Deck No. 5, -Y side	15	59	18	64		

2. Thermal-Control Paints Applied to RA-9

The paints used on the fins of the RA-9 TV Subsystem were a mixture of PV-100 white paint and MIL-E-5557 type III black paint and are identified as light gray (RCA Drawing 1758619-29) and dark gray (RCA Drawing 1758619-30), respectively. Mixtures of the gray paints were prepared in November 1964 for use on the RA-9 TV Subsystem. In an effort to obtain the same flight temperatures on RA-9 as occurred on RA-7, the solar absorptivities of the paints were decreased. This decrease allowed for the increased solar constant at the time of the anticipated March launch. The desired values of solar absorptivity for the RA-9 paints were 0.48 and 0.67 as compared with 0.51 and 0.71 for RA-7. Samples of the paint were sent to JPL for measurement at STL. The spectral-measurement history of these paints, which were used in the final finishing of the thermal shroud, is given in Table 4-6.

TABLE 4-6
SPECTRAL-MEASUREMENT HISTORY

Paint Description	Absorptivity Measured By:	Design Absorptivity Values Desired	Samples Painted at RCA (Nov. 1964)	Samples Painted During Painting of RA-9 Fins at JPL	RA-9 Fins Measured with Portable Reflectometer at ETR
Light Gray	RCA	0.48	0.49	0.49	0.49
RCA 1758619-29	JPL/STL	0.51	--	0.52	--
Dark Gray	RCA	0.67	0.65	0.65	0.65
RCA 1758619-30	JPL/STL	0.71	--	0.69	--

Measurements of absorptivity at ETR on the RA-9 thermal shroud fins were obtained using the Lion Model 25 A portable reflectometer and the RCA calibration standards. The accuracy of this reflectometer is estimated to be ± 5 percent.

Measurements indicated that an area of Fin B, on the -Y side of the shroud had absorptivity readings as low as 0.37 (below standard). The predicted temperatures indicated for the fin indicated a decrease in cruise mode temperature of less than 1°F when the substandard area was taken into consideration. Repainting (at ETR) was not considered necessary since the RA-8 flight temperatures were approximately 5°F higher than nominal. Therefore, because of the difference in the solar constants existing in February and March the RA-9 fin temperatures were expected to be 3 to 4°F higher than nominal.

3. RA-9 Cruise Mode Temperatures vs. Flight Predictions

a. Thermal Shroud Hat

The temperature of the hat was monitored during cruise mode by Channel 8 telemetry, data point No. 7. The temperature of this point was 79°F at the time of launch and decreased rapidly to 58°F because the Spacecraft was traveling in the earth's shadow. When sun and earth acquisition was established, the temperature stabilized at 79°F.

During midcourse maneuver, the temperature of the hat, which is a sheet-metal structure, increased to 124°F due to the (solar) orientation of the Spacecraft. When sun and earth were reacquired, the thermal shroud hat returned to a stabilized temperature of 79°F. During terminal maneuver, the temperature increased to 90°F and then decreased to and stabilized at 75°F for the terminal operation.

The predicted temperature range for the hat during cruise mode was from 67 to 87°F.

The hat reacts significantly to small changes in energy input because it is large in area and low in thermal mass. It is for this reason that the temperature fluctuations occur when the axis of the TV Subsystem is not normal to the sun, as is the case early in flight and during the midcourse maneuver.

b. Camera Lens Housing

The temperature of the camera lens housing was monitored during cruise mode by Channel 8 telemetry, data point No. 1. The launch temperature was 79°F. While the Spacecraft was in the earth's shadow, the housing temperature decreased to 62°F. When sun and earth acquisition was accomplished, the temperature stabilized at 63°F. The midcourse maneuver and the terminal maneuver caused an increase of 1°F in the lens housing temperature. During the last 5 hours of flight before impact, including terminal operation, the F_a Camera lens housing temperature increased 8°F. This increase in temperature was attributed to the light reflected from the moon, since no increase in temperature was experienced in environmental simulation testing.

The predicted temperature range of the camera lens housing during cruise mode was from 48°F to 68°F. The temperature increase to the camera lens housing because of light reflected from the moon was predicted, based upon the RA-7 flight data, to be between 7.5 and 8.5°F, depending upon the impact site.

c. Thermal Shroud (−Y Side, Below Fin A)

The temperature of the thermal shroud was monitored by Channel 8 telemetry, data point No. 8. The launch temperature was 80°F. While the Spacecraft was traveling through the earth's shadow, the temperature of this area decreased rapidly to 69°F. After sun and earth acquisition, the temperature stabilized at 76°F (within 20 hours from launch).

During midcourse maneuver, the temperature of this shroud increased to 98°F. When sun and earth acquisition was reaccomplished, the temperature restabilized to 76°F. During terminal maneuver, the temperature ranged from 88°F to 73°F. This temperature was 75°F when the TV Subsystem was commanded into terminal-mode operation and was 83°F before impact.

The predicted temperature range of the thermal shroud (-Y side) during stabilized cruise mode was between 60°F and 80°F. The shroud, similar in construction to the shroud hat, reacts to small changes in input energy, causing temperature fluctuations to occur when the axis of the Subsystem is not normal to the sun.

d. P-Channel Battery

The P-Channel battery was monitored during cruise mode by an internally located themistor on Channel 8 Telemetry data point No. 4. The batteries, which are high in thermal mass, were not affected by the transient changes in solar input that occurred during the midcourse and terminal maneuvers. The battery temperature steadily decreased from a launch temperature of 80°F to a stabilized cruise-mode temperature of 78°F after 40 hours of flight. During terminal-mode operation, the battery temperature increased 5°F.

The predicted temperature range of the battery during stabilized cruise mode was between 62 and 82°F.

e. Camera Electronics

The camera-electronics temperature was monitored during cruise mode by Channel 8 telemetry, data point No. 11. The reaction of this equipment to the brief changes in solar input that occurs during midcourse and terminal maneuvers is limited by the thermal mass and location within the TV Subsystem. After a launch temperature of 79°F, the temperature decreased and stabilized at 70°F within 15 hours of flight. During terminal-mode operation, there was a 7°F increase in the temperature of these units.

The predicted temperature range during stabilized cruise mode was between 54°F and 74°F.

f. Summary

Temperatures of the five points monitored during cruise mode were all within 6°F of the midpoint of the predicted range of stabilized cruise-mode temperatures. Thus, the temperatures of the Spacecraft were within the range of desirable temperatures for the initiation of terminal operation as verified during a number of tests at this same level. A comparison of test temperatures and flight temperatures for the same period of operation are listed in Table 4-7.

D. Telecommunications Group

Evaluation of telecommunications performance during the RA-9 mission is based on the r-f power transmitted by the F- and P-Channel transmitters. The data obtained during the RA-9 mission indicated that communications performance compared closely with the results of prelaunch system tests, which were nominal.

This section describes the techniques that were employed to measure the r-f power received at the ground station for each channel and the methods employed to infer the level of the power that was transmitted from the TV Subsystem Four-Port Hybrid. The results of the different power-measuring techniques vary by ±1 db; however, this is of no consequence, since the received r-f signal level was 10 db above receiver threshold. At such a strong signal level, the peak-to-peak signal-to-rms noise ratio was approximately 40 db, and no degradation of picture quality would have occurred as the result of a 2-db decrease in the received signal level.

1. RF Power Output During Terminal Mode

Three techniques were used to measure the r-f power output of the F- and P-Channel transmitters during the terminal mode of the RA-9 mission. RCA used two techniques: one employing a spectrum analyzer, and the other employing a diode detector. The third technique, used by JPL employed a filter system.

TABLE 4-7
RA-9 TEST TEMPERATURES VS. FLIGHT TEMPERATURES

Telemetry Point Location	III-4 Test Cruise Mode		III-4 Test 19 Min Full Power		III-4 Test 30 Min Full Power		RA-9 Flight Stabilized Cruise Mode Prediction		RA-9 Actual Flight Stabilized Cruise Mode		RA-9 Impact 19 Min Full Power	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
P-Channel Battery, Internal	26	79	28	82	30	86	22 +5	72 +10	26	78	28	83
F-Channel Battery, Internal	26	79	28	82	30	86	--	--	--	--	28	82
P-Channel Battery, External	24	75	27	80	30	86	--	--	--	--	--	--
F-Channel Battery, External	24	75	27	80	30	86	--	--	--	--	29	84
F_a-Camera Lens Housing	24	75	24	75	24	75	15 +5	58 +10	17	63	22	72
Camera Mounting Bracket	23	73	23*	73*	21*	70*	--	--	--	--	27	80
Camera Electronics	27	80	32	89	36	97	18 +5	64 +10	21	70	25	77
Thermal Shroud Hat (-Y)	22	71	16*	61*	13*	55*	25 +5	77 +10	26	79	24	76
Thermal Shroud Lower (-Y)	26	79	25*	77*	28*	82*	21 +5	70 +10	25	76	28	83
Thermal Shroud Lower (+Y)	27	80	22*	71*	26*	79*	--	--	--	--	42	108
Bulkhead Near P-Channel PA	27	80	40	104	49	120	--	--	--	--	41	106
Bulkhead Near P-Channel PA	27	80	46	115	56	133	--	--	--	--	50	122
Deck 5 (-X, -Y)	22	71	25*	77*	30*	86*	--	--	--	--	35	95
Deck 4 (+Y)	28	82	26*	79*	31*	88*	--	--	--	--	39	102
Deck 4 (-Y)	28	82	27*	80*	32*	89*	--	--	--	--	30	85

*Input heaters turned off during full-power operation negates true readings in this area.

a. Spectrum Analyzer

One of the outputs of the 30-megacycle isolation amplifiers at the Pioneer site was connected through a directional coupler to a spectrum analyzer as shown in Figure 4-40. A signal generator was connected to the output of the directional coupler so that the signal generator input to the spectrum analyzer was reduced 17 db. The highly directional characteristics of the coupler and the degree of isolation of the amplifier were sufficient so that the generator signal did not interfere with the JPL or the RCA receivers. This technique, which was used in all system tests and produced results within ±0.5 db, depends on the scope persistence to allow the determination of peak amplitude, which exists only during the time when there is no video. The F-Channel peak amplitude is easier to read than the P-Channel amplitude since it is modulated at a much slower rate than P-Channel. P-Channel peak amplitude is usually read 1 db below normal when the P-Cameras are fully modulated. The calculated power profile is given in Table 4-8. The power output of the Four-Port Hybrid was calculated by measuring the relative peak level of the F- or P-Channel signal with respect to the peak amplitude of the JPL beacon, and adding this to the known JPL r-f level at the output of CASE II (telemetry address 56) and to the known loss from the Four-Port Hybrid to the output of CASE II (0.99 db). The maximum power of 27.1 watts for F-Channel during the mission was equal to the F-Channel power obtained during camera calibration with both channels operating. The calibration-data used for comparison was taken during the prelaunch test. During tests, the F-Channel power has consistently maintained a maximum level for 20 minutes. Therefore, the decrease in power to 22.6 watts at impact minus 5 minutes appeared to be due to a change in maser passband. The post-impact calibration indicated that the F-Channel output was down 1.86 db relative to the JPL beacon. The pre-impact calibration was down 0.45 db.

A maximum power output of 20.9 watts for P-Channel was 0.9 db lower than the 25.6 watts expected because of reading P-Channel 1 db lower than normal. The premission calibration indicated that P-Channel was down 0.2 db from the JPL beacon; the post-impact calibration was down 0.45 db.

b. Diode Detector Power Monitor Technique

This technique measured and recorded the signal levels from the F- and P-Channel transmitters on the Spacecraft as referred to the maser input. It was thought that this technique would be an accurate means of calibration; however, the varying passband and gain of the maser amplifier reduced its accuracy. The strip-chart recordings show a smooth power profile for both transmitters for the entire 19 minutes of full-power operation. The only small variations recorded occurred when the Echo ground transmitter stopped transmission and when a gradual frequency change occurred at impact minus ten minutes because the power recording is a function of frequency.

TABLE 4-8
RA-9 POWER OUTPUT PROFILE

TIME (Minutes)	F Channel HP608 Setting (dbm)	F Channel Relative to JPL (db)	F Channel (1) Relative to JPL Corrected (db)	(3) Four-Port Hybrid Power Output (watts)	JPL HP608 Setting (dbm)	P Channel HP608 Setting (dbm)	P Channel Relative to JPL (db)	P Channel (2) Relative to JPL Corrected (db)	(3) Four-Port Hybrid Power Output (watts)
I-78	-34.7				-51.0	-34.6			
I-18' 47"	-33.0	+18.0	+18.45	22.6		-34.2	+16.8	+17.0	16.2
I-18	-32.8	+18.2	+18.65	23.7		-33.8	+17.2	+17.4	17.8
I-17	-32.7	+18.3	+18.75	24.3		-33.3	+17.7	+17.9	20.0
I-16	-32.2	+18.8	+19.25	27.1		-33.1	+17.9	+18.1	20.9
I-14	-32.2	+18.8	+19.25	27.1	-51.0	-33.2	+17.8	+18.0	20.4
I-12	-32.2	+18.8	+19.25	27.1		-33.1	+17.9	+18.1	20.9
I-10	-32.5	+18.5	+18.95	25.4		-33.1	+17.9	+18.1	20.9
I-7	-32.5	+18.5	+18.95	25.4		-33.2	+17.8	+18.0	20.4
I-5	-33.0	+18.0	+18.45	22.6		-	-	-	-
I-4	-33.0	+18.0	+18.45	22.6	-51.0	-	-	-	-
I-2	-33.0	+18.0	+18.45	22.6		-33.3	+17.7	+17.9	20.0
I-1	-33.0	+18.0	+18.45	22.6		-33.3	+17.7	+17.9	20.0
I+9	-33.8					-32.2			

(1) Using I-83' Passband correction factor of +0.45 DB
(2) Using I-83' Passband correction factor of +0.2 DB
(3) 4 Port Hybrid Power Output = (Signal level relative to JPL) + (correction Factor) +0.99 +24.10)

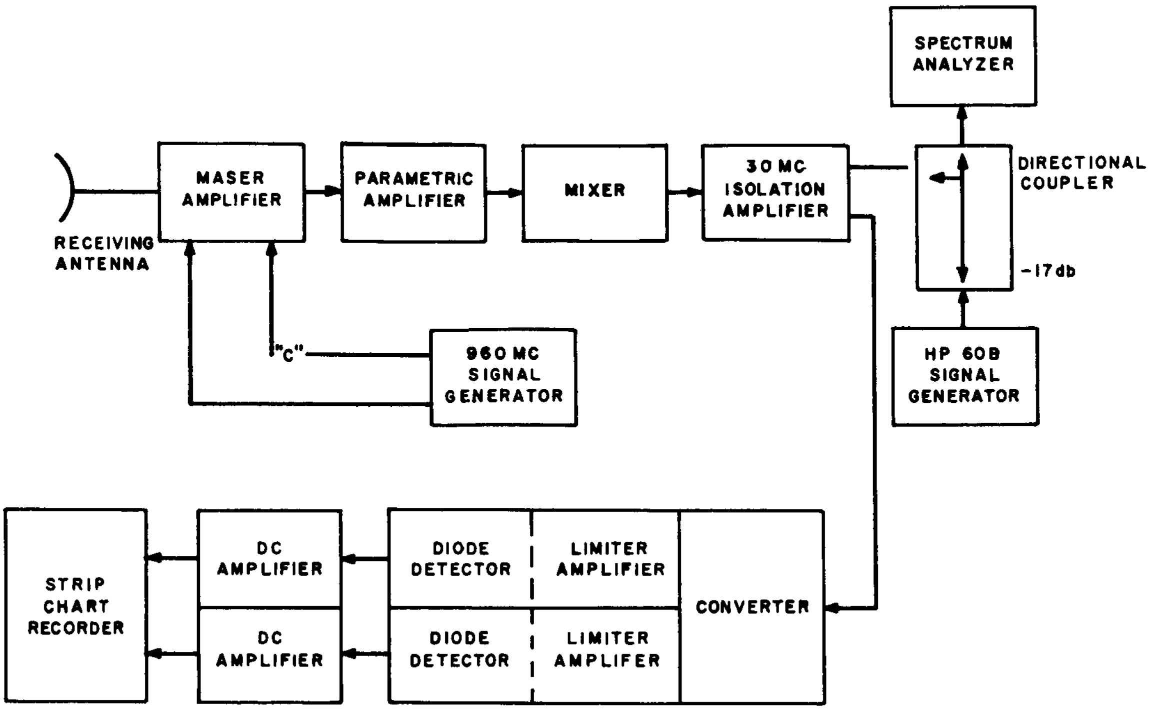

Figure 4-40. Diode-detector technique of terminal-mode power measurement

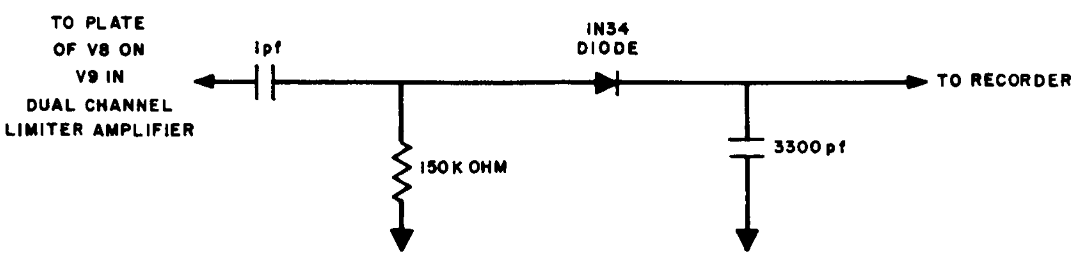

Figure 4-41. Diode-detector circuit

A block diagram of the diode detector technique is shown in Figure 4-40. The detector was connected as shown in Figure 4-41. Two of these detectors were physically incorporated in the Dual Channel Limiter Amplifier.

The d-c output from the detector varies as a function of r-f signal strength since no limiting occurs before the point at which the r-f signal is detected. The d-c signal is amplified in a Sanborn Model 150-1000A Amplifier which actuates a pen on the Sanborn Model 154-100B Recorder. A readout is obtained for each channel.

Calibration was accomplished by feeding the output of a signal generator (set to the center frequency of the appropriate channel) through the path marked "C" in Figure 4-40. The loss through the path from the maser to the RCA GSE was supplied by JPL. Based on an expected nominal mission level of -96.5 dbm, the required signal generator output level setting was obtained as follows:

Loss, maser to RCA GSE	44.51 db
Loss, signal generator cable	1.00 db
Total loss	45.51 db
Nominal mission signal level at maser	-96.5 dbm
Signal generator setting for nominal signal	-51.0 dbm

The gains of the d-c amplifiers were adjusted to provide a readout at about 3/4 scale on the recorder chart for a -96.5 dbm input level to the maser. The recorder was also calibrated in 1 db intervals for ±3 db. A calibration of the measuring equipment was performed just prior to ground-station acquisition of the Spacecraft (warmup minus 1.0 hour) and within 9 minutes after impact.

Coincident with the above calibrations, the bandwidth of the input to the maser and the maser gain were checked by JPL personnel. The input to the maser bandpass curve changed radically from pre-acquisition to post impact. Since the vertical scale of the spectrum analyzer was calibrated from the same source, the observed r-f signal relative to the JPL beacon signal was 2.5 db lower than expected. Therefore, when both F- and P-Channels appeared to be above nominal, it was an expected result. F-Channel reached a maximum of nominal plus 2.5 db and P-Channel, nominal plus 1.83 db. It was realized that a discrepancy did exist, however, since this calibration was performed close to the time of TV Subsystem turn on, it was decided not to recalibrate.

c. JPL Power Monitor Technique

In this technique, the 30-Mc signal was heterodyned to 2 Mc, which was then filtered using three separate filters centered at frequencies equivalent to 959.52 Mc (F-Channel), 960.05 Mc (JPL beacon), and 960.58 Mc (P-Channel). The F- and P-Channel filter bandwidths were measured at 900 and 750 kc, respectively. The results of a pre-mission calibration, using a test transmitter, and the actual mission indicated that both bandwidths were 900 kc.

The output of the filter was connected to a high frequency, true rms voltmeter, which has a 3-db bandwidth of 10 cps to 8 Mc. This technique produced the results, presented in Table 4-9 (these calculations are based on an assumed bandwidth of 900 kc)

TABLE 4-9
JPL POWER MEASUREMENTS

Time		Filter Outputs (dbv)		
GMT	Impact (I)	F-Channel	Beacon	P-Channel
14:06	I-2 min.	-16.0	-17.5	-16.7
14:12	I+4 min.	-37.0	-23.5	-37.0

Calculation of the F-Channel and P-Channel output powers using the JPL power-monitor technique is as follows:

<u>F-Channel</u>

(1) The output of the F-Channel filter at impact minus 2 minutes was -16.00 dbv;

(2) The output of the F-Channel filter after impact (antenna still pointing at moon) was -37.0 dbv;

(3) $C/N = {}^{C + N}/_{N} = 21.0$ db

(4) System noise level (N) at the input to the maser amplifier is kTB,

where

k is Boltzman's constant;

T is receiver temperature, and

B is the bandwidth of the F-Channel filter;

Therefore,

$$N = -198.6 \text{ dbm} + 10 \log 140°K + 10 \log (900 \times 10^3)$$

$$N = -198.6 \quad + 21.46 \quad + 59.52$$

$$N = -117.62 \text{ dbm}$$

(5) Therefore, the signal level at the input to the maser amplifier for F-Channel is C = -96.62 dbm.

(6) Losses from Four-Port Hybrid to maser input = 140.84 db

Losses	1.37	JPL Spacecraft
	0.30	Antenna Pointing
	0.14	Polarization
	204.00	Space loss for distance = 394,592 km
	0.53	Receiver Circuit
	-19.90	S/C Antenna Gain
	-45.60	Goldstone Antenna Gain
	140.84 db	

(7) The F-Channel output of the Four-Port Hybrid is then

$$P = 96.62 + 140.84$$

$$P = +44.22 \text{ dbm}$$

$$P = \underline{26.5 \text{ watts}}$$

P-Channel

$$\text{P-Channel Power output at Four-Port Hybrid} = \frac{C + N}{N} - N + \text{Losses}$$

$$= -16.7 + 37.0 \quad -117.62 + 140.84 = + 43.52 \text{ dbm}$$

$$P = \underline{22.5 \text{ watts}}$$

d. Telemetry Verification

The telemetry indicated that both F- and P-Channels achieved nominal power output. F- and P-Channel IPA cathode currents were also normal.

2. Transmitters

a. Center Frequency

The center frequencies obtained during the mission, given in Table 4-10, are very close to those obtained on launch day. For approximately 30 seconds at Impact minus 10 minutes, there were variations of ±15 kc as the operator manually tuned the ground local oscillator, which was performed after the ground transmitter stopped transmission because of an overloaded circuit breaker. The final local oscillator setting was approximately 12 kc below nominal.

TABLE 4-10
CENTER FREQUENCIES OBTAINED DURING THE RA-9 MISSION

Time		F-Channel		P-Channel	
		Sync Tip (Volts)	Center Frequency Drift (±kc)	Sync Tip (Volts)	Center Frequency Drift (±kc)
T*+0	I**-20				
T+1'20	FP + 0	-0.904	-10.1	-0.880	+50.8
T+2'20"	FP + 1	-0.886	+40.1	-0.880	+50.8
3'20"	FP + 2	-0.886	+40.1	-0.880	+50.8
4'20"	FP + 3	-0.892	+20.3	-0.871	+80.4
5'20"	FP + 4	-0.893	+20.0	-0.868	+90.3
6'20"	FP + 5	-0.895	+10.4	-0.864	+100.4
7'20"	FP + 6	-0.896	+10.2	-0.856	+120.8
8'20"	FP + 7	-0.896	+10.2	-0.852	+14
8'50"	FP + 7.5	-0.894	+10.7	-0.852	+14
9'50	FP + 8.5	-0.896	+10.2	-0.850	+15
(1)		= 40 mv	= +12kc	= +49 mv	= +14kc
	FP+11 I-8	-0.855	+13	-0.801	+29
	I-7	-0.855	+13	-0.795	+30
	I-6	-0.855	+13	-0.791	+32
	I-5	-0.855	+13	-0.787	+33
	I-4	-0.851	+14	-0.785	+33
	I-3	-0.849	+15	-0.780	+35
	I-2	-0.851	+14	-0.775	+36
	I-1	-0.850	+14	-0.771	+37
	I	-0.850	+14	-0.766	+39

*T = Warmup = 134h 8m 13s after launch.
**I = Impact
(1) Ground Transmitter Shut off due to circuit breaker at I-10 minutes.

b. Frequency Stability

The frequency of the F-Channel carrier signal drifted 5 kc during the 19-minute full-power mode, as expected. The center frequency of the P-Channel carrier signal was 20 kc above nominal, as expected.

c. Deviation

Deviation of the F- and P-Channel carriers was normal.

d. Frequency Response

The F- and P-Channel frequency responses were normal.

3. Telemetry Assembly

a. Cruise Mode

All telemetry components performed nominally during cruise mode. The 15-point telemetry contained some noise due to interchannel modulation, however, it did not introduce an error exceeding one percent.

b. Terminal Mode

The frequency of the F- and P-Channel 225-kc VCO's were within the linear range of 225-kc discriminators in the ground station. The 15- and 90-point telemetry data, as received from the F- and P-Channel transmitters, were accurate and free of noise. The maximum difference between functions that were common to 15-point (F-Channel 225-kc VCO) and 90-point (P-Channel 225-kc VCO) telemetry or 90-point (Channel 8 JPL beacon) was one percent, which is excellent for a system that was designed to operate within ±5 percent.

E. Controls Group

1. Satisfaction of Mission Requirements

The operation of the TV Subsystem command and control circuitry was normal during the RA-9 mission. The TV Subsystem Clock was inhibited by an RTC-5 command after the start of the terminal maneuver. The TV Subsystem turn-on was then initiated by the CC&S (TV-2) command. Full-power operation was initiated by outputs from the F- and P-Channel 80-second timers in the Sequencer Assembly. No irregular or anomalous operation of the Controls Group was observed throughout the mission.

Some functions of TV command and control, such as F- and P-Channel turn-off by RTC-5, TV warmup via command RTC-7, and the free-run capability of the P1 Camera, were not exercised, and no statement can be made concerning performance in these areas.

2. Clock Inhibit Philosophy

The performance of the midcourse maneuver was delayed to allow for more accurate correction of the Spacecraft trajectory. As a result of this delay, the TV Subsystem Clock would have turned on F-Channel earlier than desired. The decision to send an RTC-5 command and turn off the Clock was made by SDAT as a result of the following considerations:

- Little, if any useful information could be obtained from an early F-Channel turn-on via the Clock.
- Ranger VIII had a noisy P-Camera, during a 23-minute full-power mission, which was attributed in part to the length of operation of the cameras and, consequently, to the higher operating temperature.
- F-Channel full-power operation for 43 minutes could have resulted in a higher temperature than experienced during any RA-9 testing for the F-Channel IPA. However, this higher temperature would have been within the designed capability of the transmitter.
- Optimum picture quality was desired. It was felt that the cameras would probably perform satisfactorily during a 43-minute F-Channel and 10-minute P-Channel full-power mission with little degradation, but a shorter mission was preferred.

With no real benefit of an early F-Channel turn-on and the possibility of minor degradation with the longer mission, an RTC-5 command was sent to inhibit the Clock.

3. Evaluation of Performance

a. Electronic Clock

The performance of the Clock during the RA-9 mission was satisfactory. The Clock was started by a microswitch closure that occurred when the Spacecraft separated from from the Agena.

All Clock telemetry pulses up to and including the 48-hour pulse occurred within the specified time limits. The Clock was turned off by an RTC-5 command after the start of the terminal maneuver. Telemetry confirmation of Clock turn-off occurred after RTC-5 verification by JPL.

The nominal and actual elapsed time of each Clock telemetry pulse is given in Table 4-11. If an RTC-5 command had not been sent, Clock turn-on, determined by extrapolation, would have occurred at 63 hours 31 minutes 13 seconds elapsed time or 73 seconds later than nominal, which is within the allowable 5-minute tolerance.

Comparison of flight and test performance of the Clock is given in Table 4-12.

TABLE 4-11
PREDICTED AND ACTUAL ELAPSED TIMES OF CLOCK TELEMETRY PULSES

Telemetry Pulse	GMT	Elapsed Time from Clock Starts	
		Actual*	Nominal
Start (Agena Separation)	21:52:26	S+0	S+0
1	05:52:36	S+8 hr 10 sec	S+8 hr
2	13:52:47	S+16 hr 21 sec	S+16 hr
3	21:52:54	S+24 hr 28 sec	S+24 hr
4	05:53:01	S+32 hr 35 sec	S+32 hr
5	21:53:28	S+48 hr 1 min 2 sec	S+48 hr

* Measurement accuracy is plus 0, minus 15 seconds.

TABLE 4-12 COMPARISON OF FLIGHT AND TEST PERFORMANCES OF ELECTRONIC CLOCK			
Test	Temperature	Date	Performance*
AED Simulated Mission Test (Thermal-Vacuum)	59°F to 95°F	11-27-65	63.5 hr + 56 sec
JPL Mission Test No. 1 (Thermal-Vacuum)	98°F	1-22-65	63.5 hr - 10.5 sec
ETR Clock Test	78°F	2-26-65	63.5 hr + 36 sec
Mission	70°F	3-24-65	63.5 hr + 73 sec**
* Measurement accuracy is plus 0, minus 15 seconds ** Extrapolated with an accuracy of ±10 seconds			

b. Sequencer 80-Second Timer Circuits

The F- and P-Channel 80-second timers in the Sequencer Assembly operated properly during the mission. The timers were started at TV Subsystem warmup upon receipt of the warmup command from the Spacecraft Bus as part of the terminal maneuver sequence. Timer periods observed during the mission are given in Table 4-13.

TABLE 4-13 80-SECOND TIMER PERIODS DURING RA-9 MISSION			
	Start Warmup (GMT)	Start Full Power (GMT)	Timer Period (seconds)
P-Channel	13:48:13.5	13:49:33.8	80.3
F-Channel	13:48:13.5	13:49:34.8	81.3

Comparison of flight and test performances for the F- and P-Channel 80-second timers is given in Table 4-14.

TABLE 4-14 COMPARISON OF FLIGHT AND TEST PERFORMANCES OF F- AND P-CHANNEL 80-SECOND TIMERS				
Test	Temperature (°F)	Date	Timer Period (Seconds)	
			P-Channel	F-Channel
Flight Acceptance Test	31	5-1-64	79.1	81.3
	132	5-1-64	80.3	80.9
RA-9 Actual Mission	85*	3-24-65	80.3	81.3
*Accuracy is ±5°F				

c. Command Control Unit (CCU)

Operation of the CCU was normal during the mission. Cruise-mode turn-on was initiated prior to the launch by a Cruise On Test command through the umbilical connector.

The operation of the Clock 32-hour enable relay circuit was verified by the reset of the Clock during the terminal maneuver sequence through the use of an RTC-5 command.

d. Distribution Control Unit (DCU)

The DCU operated satisfactorily during the mission. The Clock power relay circuit functioned normally. Since the TV Subsystem performance was without failure, the fuses in the DCU that could have protected portions of the Subsystem in the event of a failure were not needed.

e. High-Current Voltage Regulator Control Module (HCVR)

All portions of the control module in the F- and P-Channel HCVR's, which were exercised, performed normally. The fail-safe turn-on features incorporated in this module functioned properly.

F. Power Group

The Power Group of the RA-9 TV Subsystem consisted of the F- and P-Channel Batteries, the F- and P-Channel High-Current Voltage Regulators (HCVR), and the Low-Current Voltage Regulator (LCVR). The performance of all assemblies of the Power Group was normal during the RA-9 mission.

a. Batteries

The F- and P-Channel Batteries performed nominally throughout the mission. Figures 4-42 and 4-43 show the budgeted and expended power capacities of the F- and P-Channel Batteries for each phase of the RA-9 mission. Capacities of 29.1 ampere-hours and 34.2 ampere-hours were budgeted for the F- and P-Channel Batteries, respectively. Of that amount, 12.5 ampere-hours and 21.8 ampere-hours for the respective batteries were expended during the mission. F-Battery temperatures were between 79 and 84°F throughout the mission. This range is within the specified limits and is the ideal operating temperature range for the batteries. P-Battery temperatures, as given by the 90-point telemetry during terminal mode, were between 87 and 96°F. However, this point was erratic prior to launch. From the results of the RA-7 and RA-8 missions, it was found that all battery thermistors were within several degrees of one another. Since three of the four thermistors were within 2 degrees of each other and since the erratic thermistor varied from the group by 9 to 12°F, this reading was discredited.

F- and P-Battery voltages obtained during cruise mode by the 15-point telemetry are shown in Figure 4-44. The F-battery voltage and current from the start of terminal maneuver to impact are shown in Figure 4-45. The portion of the mission from the start of terminal maneuver to TV Subsystem turn-on was obtained from 15-point telemetry; the portion from Subsystem turn on to impact was obtained from 90-point telemetry. P-Battery terminal voltage and current are shown in Figure 4-46.

The F-Battery voltage was approximately 36 volts at launch, under a no load condition. From Clock start, at launch plus 15 minutes, to TV Clock disable, at approximately 30 minutes before TV turn-on, the F-Battery supplied 0.040 ampere for Clock operation. Just prior to Clock disable, the F-Battery voltage was 34.8 volts. At Clock disable, the 0.040-ampere load was removed and the battery voltage increased to 35.3 volts. At warmup, the current drain on the F-Battery was 7.8 amperes and the voltage was 33.2 volts. In full-power operation, the F-Battery current drain was 12.5 amperes and the voltage was 32.6 volts. P-Battery supplied 0.160 ampere for cruise-mode telemetry from launch minus 15 minutes, in the countdown, to Subsystem warmup. P-Battery voltage at launch was 34.9 volts. Just prior to Subsystem warmup, P-Battery

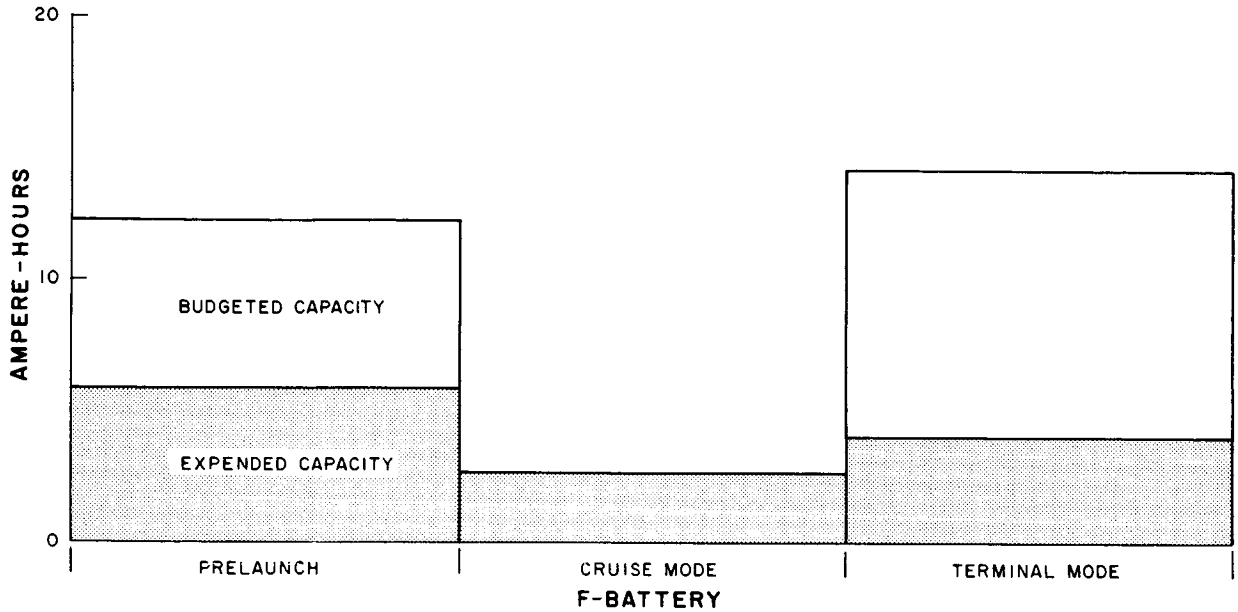

Figure 4-42. F-Channel budgeted and actual battery capacities

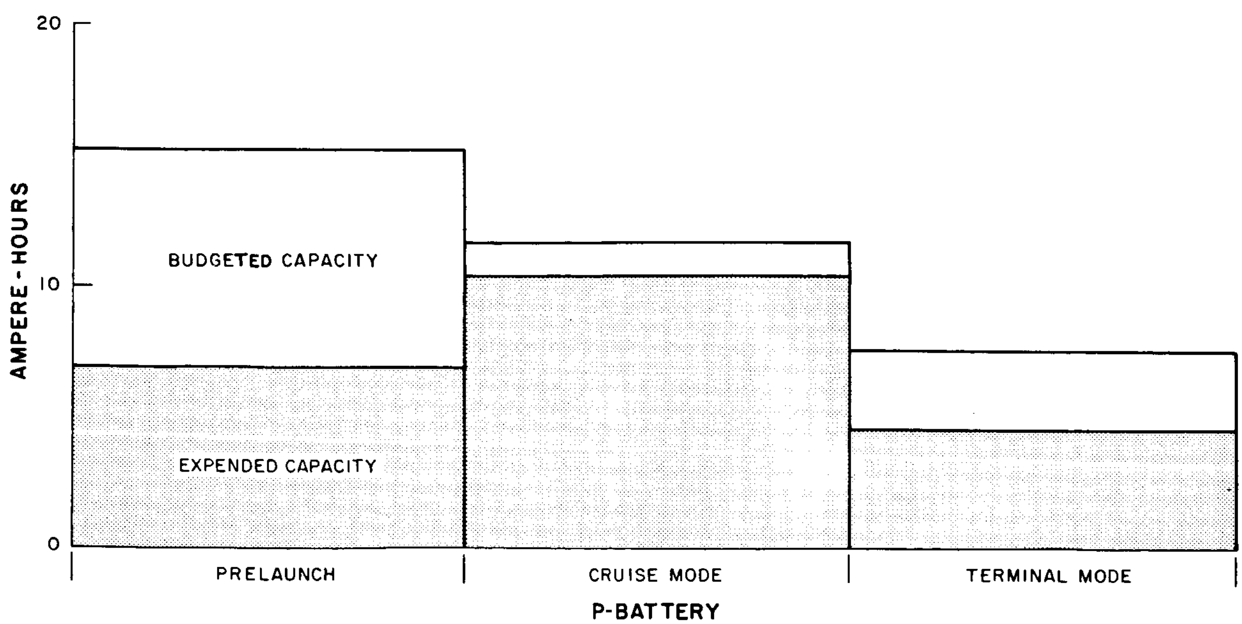

Figure 4-43. F-Channel budgeted and actual battery capacities

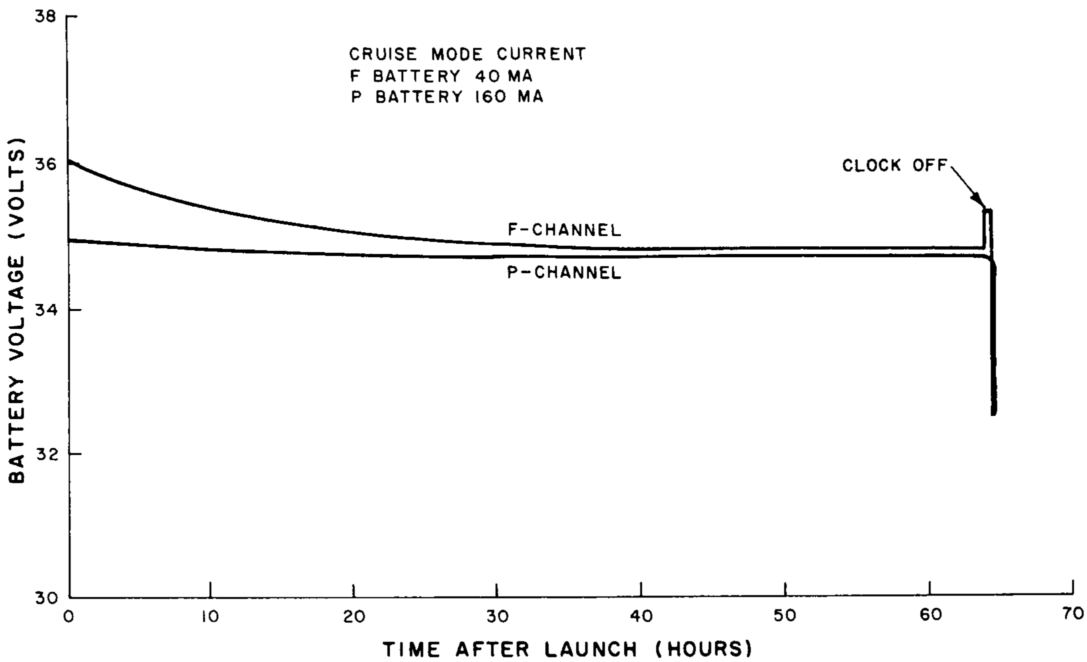

Figure 4-44. F- and P-Battery voltage profiles obtained from 15-point telemetry

voltage was 34.7 volts. At warmup the current drain was 8.6 amperes and the voltage was 32.8 volts. At full power, the current drain was 14.3 amperes and the voltage was 32.5 volts. The battery specification is a minimum of 30.45 volts.

b. Voltage Regulators

The output of the Low-Current Voltage Regulator (LCVR) was constant at 27.5 volts from launch to Subsystem turn-on. At turn on, the voltage dropped to -27.4 volts because this regulator-supplied part of the 90-point telemetry load. Design specifications for the Low-Current Voltage Regulator call for an output voltage of -27.5 ±0.5 volts. The output of the F- and P-Channel High-Current Voltage Regulators (HCVR) was -27.7 and -27.6 volts, respectively. Both regulators were within design specifications of -27.5 ±0.5 volts.

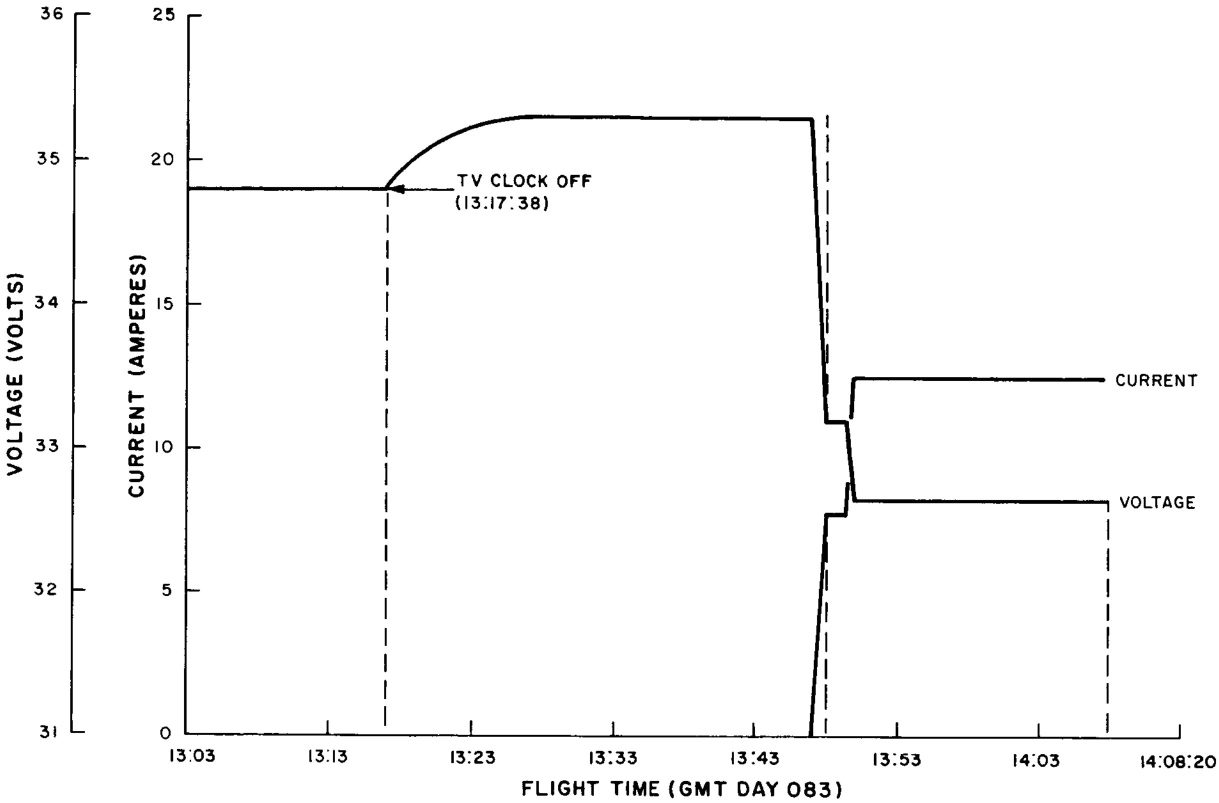

Figure 4-45. F-Battery voltage and current from terminal maneuver to impact

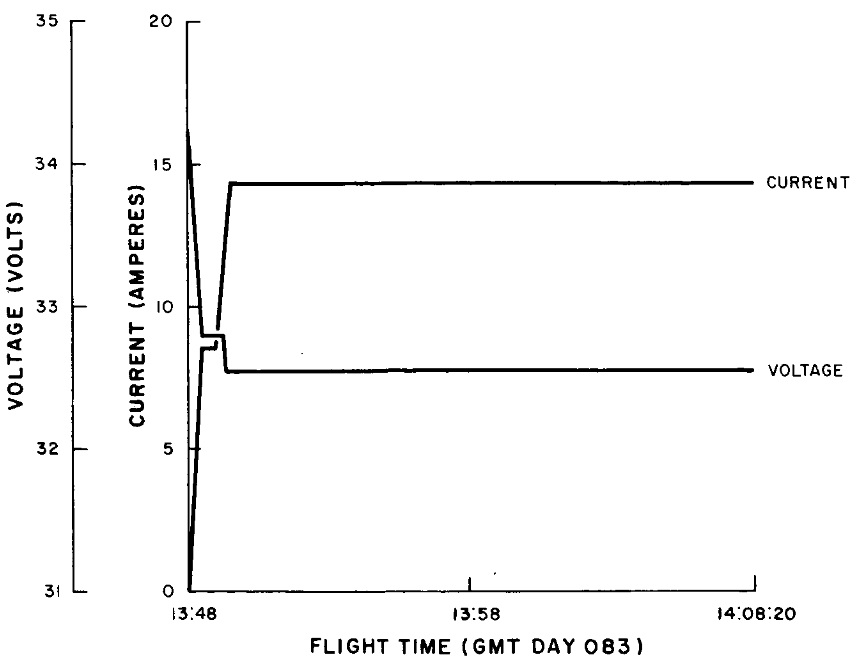

Figure 4-46. P-Battery voltage and current during terminal-mode

Section V

Conclusions

The performance of the Ranger IX TV Subsystem met or exceeded all mission objectives. Both wide area coverage with frame-to-frame nesting, and high resolution pictures were obtained. The successful performance of a terminal maneuver by the spacecraft, coupled with a desirable trajectory, enabled the full potential of the camera performance to be realized in the final series of partial- and full-scan pictures. The best resolution of approximately 1.0 feet per optical line pair was obtained by the last P1 and F_b camera pictures. Transmitter power level was consistent with previous test experience and the received signal level was 10db above receiver threshold. A review of cruise- and terminal-mode telemetry indicates that all subsystem equipment groups functioned properly during the entire flight.

The combination of trajectory, Spacecraft and TV Subsystem performance all contributed to the completion of a highly successful mission.

Appendix A

Testing of Flight Model III-4 TV Subsystem at JPL

A. General

This appendix is a continuance of the test history of Flight Model III-4 TV Subsystem. The test program was initiated with Subsystem testing at RCA. The results of that test phase were reported in "Test Report for Flight Model III-4 Ranger TV Subsystem", issued February 17, 1965. The second phase of the test program-System tests at JPL is described herein.

The purpose of the tests performed at JPL was to verify the performance of the electronic equipment in the TV Subsystem and the electrical integrity of the TV Subsystem integrated with the Spacecraft Bus. These tests were designed to verify the satisfactory operation of the TV Subsystem in ambient, simulated-launch, and simulated-flight (space) environments. The test program also served to verify the procedures and operational readiness of the Ground Support Equipment used to check out the integrated Spacecraft prior to launch.

This appendix provides a brief description of each test performed on Flight Model III-4, together with an evaluation of the test data obtained. Analysis of each malfunction report (MR) referenced in the appendix is presented in Table C-1 of Appendix C. Flight Model III-4 TV arrived at JPL on December 4, 1964, and the test phase commenced on December 5, 1964. The test program of Flight Model III-4 at JPL is summarized in Table A-1.

B. Initial Test Phase

1. Post-Shipment Electrical Test (RTSP 1100A, Appendix R)

The post-shipment electrical test was performed on December 5, 1964, in accordance with RCA Specification RTSP-1100A, Appendix R.

TABLE A-1
TV SUBSYSTEM TESTS AT JPL

Title of Test	Date	Test Procedure
Post-Shipment Electrical Test	12/5/64	RTSP 1100A, Appendix R.
Camera Gain Adjustment Evaluation Test	12/9/64	RTSP 1100F1, Appendix R (Modified)
TV Subsystem Checkout	12/9/64	JPL Procedure 3R212. 05
System Test No. 2	12/10/64	JPL Procedure 3R300. 17
Backup Function System Test	12/14/64	JPL Procedure 3R305. 08
System and EMI Test No. 3	12/17/64	JPL Procedures 3R300. 18 and 3R409. 02
ESF Television Full Power - RF Test	12/21/64	JPL Procedure 3R235. 03
TV Subsystem and Shroud Light Compatibility, and RF Losses Test	12/28/64	JPL Procedure 3R405. 03
ESF Operational Checkout	12/29/64	JPL Procedure 3R317. 03
Pre-Countdown Dummy Run	12/30/64	JPL Procedure 3R303. 07
Countdown Dummy Run	12/30/64	JPL Procedure 3R308. 06
Pyrotechnic Extension Test	1/6/65	JPL Procedure 3R313. 07
X-Axis Vibration Test	1/8/65	JPL Procedure 3R311. 05
Y-Axis Vibration Test	1/9/65	JPL Procedure 3R311. 05
Tortional Vibration Test	1/11/65	JPL Procedure 3R311. 05
Z-Axis Vibration Test	1/12/65	JPL Procedure 3R311. 05
Post-Vibration System Test No. 4	1/14/65	JPL Procedure 3R300. 19
Pre-Mission Verification Test	1/19/65	JPL Procedure 3R302. 09
Mission Test No. 1	1/22/65	JPL Procedure 3R302. 09
Mission Test No. 2	1/22/65	JPL Procedure 3R302. 09
Pre - RF Link Verification Test	1/27/65	JPL Procedure 3R320. 03
RF Link Verification Test	1/27/65	JPL Procedure 3R320. 03
Directional Antenna Deployment Test	1/30/65	JPL Procedure 3R243. 01
TV Subsystem Tilt Test	2/1/65	Special Test
TV Subsystem Evaluation Test	2/8/65	Special Test
Pre-Shipment System Test	2/11/65	JPL Procedure 3R300. 19
Special F_a Camera Test	2/11/65	Special Test

a. Purpose of Test

The purpose of this test was to demonstrate that the TV Subsystem was not damaged during shipment from RCA to JPL, and to verify that Subsystem performance was not affected by shipment.

b. Description of Test

The thermal shrouds and top hat were removed, and a hardline connection between the 4-port hybrid and OSE was made. To check the performance of the cameras, a light gun was used as a source of illumination and the video output was observed on the monitor display. The test was performed using external (OSE) power.

The test comprised two full-power sequences. During the first sequence, an RTC-7 command was used to set the TV Subsystem to the warmup mode of operation. The full-power mode was then effected by outputs from the 80-second timers. During the second sequence, CC&S warmup and full-power commands were used to control the TV Subsystem.

c. Test Evaluation

Review of the 35-mm film record and Polaroid pictures taken during the test indicated that all the cameras operated satisfactorily. The performance of communications, telemetry, and command and control circuitry was normal. The test demonstrated that the performance of the TV Subsystem was not detrimentally effected by shipment.

2. Camera Gain Adjustment Evaluation Test (RTSP 1100A, Appendix R Modified)

The camera gain adjustment evaluation test was performed on December 9, 1964, in accordance with a modified RCA Specification RTSP 1100 A, Appendix R.

a. Purpose of Test

The purpose of this test was to evaluate the performance of the F- and P-Cameras after the gain levels of the cameras and collimator were reset.

Furthermore, the test served to verify the TV Subsystem operation prior to TV Subsystem Checkout, and the test results were to serve as a reference for evaluation of subsequent tests.

b. Description of Test

For this test, the thermal shrouds and top hat were mounted on TV Subsystem, and the collimators were installed on the cameras. While the batteries were on-board during the test, OSE power was used to operate the Subsystem. The test comprised two sequences and the procedure was identical to that used in the post-shipment test.

c. Test Evaluation

The resolution of each camera was obtained by observing the collimator-projected RETMA charts and the results were as follows: for F_a Camera, 720 TV lines; F_b Camera, 780 TV lines; P1 and P2 Cameras, 200 TV lines; and P3 and P4 Cameras, 225 TV lines. The test results were accepted as a reference in evaluation of subsequent tests.

3. TV Subsystem Checkout (JPL Procedure 3R212.05)

The TV Subsystem Checkout was performed on December 9 and December 11, 1964, in accordance with JPL Procedure 3R212.05.

a. Purpose of Test

The purpose of this test was to verify electrical compatibility of the TV Subsystem with the Spacecraft Bus; to establish the operational readiness of the TV Subsystem by performing a functional checkout; to verify proper operation of the 890-Mc Transponder/Receiver in the Spacecraft Bus; and to verify r-f compatibility between the r-f components of the TV Subsystem and Spacecraft Bus when the TV Subsystem is operating in the full-power mode and radiating on the high-gain antenna.

b. Description of Test

The TV Subsystem, in the same configuration as the previous test, was mated to the Spacecraft Bus. The test was performed in two parts. First part was performed on December 9, 1964, and comprised the complete TV Subsystem checkout procedure, except for the r-f compatibility test. This part of the checkout was performed using external power and r-f hardline connection. Next, System Test No. 2 which is described later, was performed. Finally, on December 11, 1964, the second part of the checkout was completed. The second part of the test was performed using internal (battery) power and r-f probe instead of external power and hardline connection. It comprised the r-f compatibility test and a repetition of the 890-Mc Transponder/Receiver checkout.

c. Test Evaluation

Test data were reviewed, and it was determined that the TV Subsystem met all the requirements imposed by the TV Subsystem checkout procedure.

C. System Test Phase

1. System Test No. 2 (JPL Procedure 3R300.17)

The system test No. 2 was performed on December 10, 1964, in accordance with JPL Procedure 3R300.17.

a. Purpose of Test

The purpose of this test was to verify proper TV Subsystem operation when the Spacecraft is subjected to an accelerated mission simulation at ambient conditions.

b. Description of Test

The Spacecraft configuration was not changed from the previous test, and direct-access cables were used between TV Subsystem and OSE. The TV

Subsystem was set to terminal mode of operation by means of the RTC-7 command and the 80-second timer, and it remained in full power for 13.7 minutes. During the test, strip-chart recordings of telemetry and r-f outputs were obtained, and 35-mm and Polariod pictures of video outputs of the cameras were obtained. The test was performed using external power.

c. Test Evaluation

The resolution of each camera was obtained by observing the collimator-projected RETMA charts, and the results were as follows: for F_a Camera, 780 TV lines; F_b Camera, 790 lines; P1 and P2 Cameras, 200 TV lines; P3 Camera, 252 TV lines; and P4 Camera, 238 TV lines. Both F- and P- Channel outputs were measured to be 54.6 watts, and telemetered data were normal. The TV Subsystem operation was deemed satisfactory.

2. Backup Functions System Test (JPL Procedure 3R305.08)

The backup functions system test was performed on December 14, 1964, in accordance with JPL Procedure 3R305.08.

a. Purpose of Test

The purpose of this test was to verify that the backup functions of the Spacecraft would provide the required command redundancy. Those command functions that were not exercised during system test No. 2 were checked during this test.

b. Description of Test

The Spacecraft was operated in the same manner as for system test No. 2, except that failure modes of primary functions were simulated. The TV Subsystem was monitored for proper operation when activated by means of the backup function commands. The commands that were tested: Agena Separate Microswitch, Hydraulic Timer Command, Solar Panel TV Arming Microswitch, CC&S Warmup Command, and Cruise on Test Command. This test was performed using external power.

c. Test Evaluation

The performance of TV Subsystem during the backup function test was normal. Examination of 35-mm film, however, disclosed reduced video amplitude on the first frame of F_a-Camera output. This problem was attributed to transients generated by the full-power relays (MR 2263). Furthermore, the TV Subsystem was incorrectly put into warmup by an inadvertent CC&S command from the Bus during the test. This was due to CC&S operator error. The incorrect placement of the system into warmup caused a perturbation in the otherwise normal telemetry data; F-Battery terminal voltage, as indicated by 15-point telemetry, was low at the beginning of the telemetry strip pulse, but increased quickly toward its normal value during the pulse.

3. System and EMI Test No. 3 (JPL Procedure 3R300.18 and 3R409.02)

The system and electro-magnetic interference (EMI) test No. 3 was performed on December 17, 1964, in accordance with JPL Procedures 3R300.13 and 3R409.02.

a. Purpose of Test

The purpose of this test was to ensure that the r-f levels encountered during launch-pad operations do not interfere with Spacecraft functions.

b. Description of Test

The Spacecraft configuration and the operating procedure were the same as in system test No. 2. During the test, the Spacecraft was irradiated by sources which simulated all launch vehicle and ETR r-f equipment in the vicinity of the launch pad. The TV Subsystem was monitored during the test, and if any interference was detected, the cause was located by successively turning off the r-f sources.

c. Test Evaluation

The resolution of each camera was obtained by observing the collimator-projected RETMA charts, and the results were as follows: for F_a Camera, 770 TV lines; F_b Camera, 800 TV lines; P1 and P2 cameras, 225 TV lines; and

P3 and P4 Cameras 238 TV lines. The operation of the TV Subsystem was considered normal in spite of the following occurrences. During the test, the output of F-Channel VCO was found to be 3 db higher than normal. This was due to an impedance mismatch between the VCO output and IF modulator (MR 2264). Furthermore, the black-field presentation of the F-Cameras on the OSE A-scope exhibited high-frequency noise bursts, which, however, did not show on the 35-mm film record. This noise was attributed to switching transients in the GSE Monitor and Control Cabinet (MR 2265).

D. ESF Simulation Test Phase

1. ESF Television Full Power RF Test (JPL Procedure 3R235.03)

The explosive-safe facility (ESF) full-power RF test was performed on December 21, 1964, in accordance with JPL Procedure 3R235.03.

a. Purpose of Test

The purpose of this test was to check the r-f connection between the TV Subsystem and Communications Case II of the Spacecraft Bus, and to verify that the r-f path between the TV Subsystem and the directional antenna operates properly during full-power operation. A further purpose of the test was to verify that the radiated r-f does not degrade the pyrotechnics at ESF.

b. Description of Test

The Spacecraft was mounted on the system test stand, and the directional antenna was installed in its nested position. Microwave absorbent material was placed beneath the directional antenna and a calibrated r-f probe was installed to monitor the r-f power output. A new set of batteries was installed in both the TV Subsystem. The TV Subsystem was operated in full-power mode, and the r-f power at the output of the directional antenna was measured for the duration of the 5-minute full-power operation. To test the operation of the cameras, a white-surfaced board was placed in front of the cameras and illuminated with flood lights.

c. Test Evaluation

The performance of TV Subsystem was normal. During the cruise mode of operation, the zero-reference frequency of Channel 8 VCO was measured and found to be 3032.3 cps.

2. TV Subsystem and Shroud Light Compatibility, and RF Losses Test (JPL Procedure 3R405.03)

The TV Subsystem and shroud lights compatibility, and r-f losses test was performed on December 28, 1964, in accordance with JPL Procedure 3R405.03.

a. Purpose of Test

The purpose of this test was to verify the proper operation and alignment of the Agena shroud lights with the six TV camera array, and to determine the r-f transmission losses of the omnidirectional and directional antennas when the shroud is installed.

b. Description of Test

With the Agena shroud installed, the TV Subsystem operation was initiated by an RTC-7 command, and the 80-second timer switched the Subsystem into reduced power mode. The test was terminated with an RTC-5 command. The compatibility and alignment of the TV Subsystem cameras with the locations of the Agena shroud lights were checked by viewing the lights on the TV monitors. Furthermore, the r-f transmission losses of the omnidirectional antenna were measured at the shroud r-f coupler, and the directional antenna losses were measured with a probe located in the LMSC mock-up forward equipment rack. The test was performed using battery power.

c. Test Evaluation

The performance of TV Subsystem was normal, except that one of the shroud lights was obscured from the field of view of the F-Cameras. After the test, Agena shroud was removed, and the light was found to be recessed too far into the lining of the shroud. Since each of the cameras was illuminated by at least one light, no further action was taken at the time. During the test, some radio-frequency interference (rfi) was noted at the output of F_b and P4 Cameras.

E. Launch Pad Simulation Tests

1. ESF Operational Checkout (JPL Procedure 3R317.03)

The ESF operational checkout was performed on December 29, 1964, in accordance with JPL Procedure 3R317. 03.

a. Purpose of Test

The purpose of this test was to provide a cross-check of TV Subsystem performance and to verify that RTC-7 commands will not effect the turn-on of the TV Subsystem while the "ground bus enable function" is reset. In addition, this served as a check of the test susceptibility of the Subsystem to emi and rfi.

b. Description of Test

The Spacecraft was in flight configuration, with the Agena shroud installed. It was mounted on the transporter, and powered from batteries. To enable an evaluation of the cameras, the shroud lights were checked and installed. The TV Subsystem was commanded from the Blockhouse Simulator Trailer and the terminal mode was initiated by means of RTC-7 reduced-power command.

c. Test Evaluation

The performance of TV Subsystem was normal. Examination of the 35-mm film containing the F_a-Camera display showed the shroud light that was obscured during the previous test; the light, however, did not show within the field of view of F_b Camera.

At the start of the reduced-power mode of operation, both communications and beacon signals were transmitted over the directional antenna, and some noise was evident at the outputs of all cameras. After the beacon signal was switched to the omnidirectional antenna, the noise level at the output of F_b Camera increased to 100 millivolts; the noise at the output of all the remaining cameras was nominal.

2. Pre-Countdown Dummy Run (JPL Procedure 3R303.07)

The pre-countdown dummy run was performed on December 30, 1964, in accordance with JPL Procedure 3R303.07.

a. Purpose of Test

The purpose of this test was to familiarize the test personnel with the prelaunch checkout procedures used at ETR, and to verify the compatibility of Blockhouse Launch Complex Equipment with the Spacecraft.

b. Description of Test

The Spacecraft was mounted on the Agena adapter and the Agena shroud was installed. During the cruise-mode operation, the TV Subsystem was tested to verify that an RTC-7 command would not effect the turn-on of the TV Subsystem while the "ground bus enable function" is reset. The Subsystem was then operated in a reduced-power mode, and the Agena shroud lights were observed on a monitor to ensure that the TV Subsystem was functioning properly.

c. Test Evaluation

The performance of TV Subsystem was normal. A measurement of combined output from F- and P-Channels was made during the test, and was found to be 289 milliwatts. This measurement was not a specified step in the JPL procedure.

3. Countdown Dummy Run (JPL Procedure 3R308.06)

The countdown dummy run was performed on December 30, 1964, in accordance with JPL Procedure 3R308.06.

a. Purpose of Test

The purpose of this test was to simulate the launch countdown and to verify that all Spacecraft systems are operating properly. Furthermore, the purpose of the test was to familiarize the personnel with the pre-launch checkout procedures and to verify the compatibility of Blockhouse Launch Complex equipment with the Spacecraft.

b. Description of Test

The configuration for this test was the same as for pre-countdown dummy run, except that simulated ETR and launch-vehicle EMI sources were used to simulate the launch environment. The test procedure that was followed in checking the TV Subsystem was the same as that used for the preceding test. However, because of an operator error, a portion of the sequence was repeated, and the Subsystem was operated for 4.5 minutes in the reduced power mode instead the usual 2.5 minutes.

c. Test Evaluation

The test results were similar to those obtained for the ESF Operational Checkout. The operation of the TV Subsystem was normal. As in the previous tests the combined output from P- and F-Channels was measured and found to be 271 milliwatts.

F. Pyrotechnic Extension Test

1. Pyrotechnic Extension Test (JPL Procedure 3R313.07)

The pyrotechnic extension system test (r-f link) was performed on January 6, 1965, in accordance with JPL Procedure 3R313.07.

a. Purpose of Test

The purpose of the test was to verify proper operation of the Pyrotechnic equipment with live squibs installed and with the Spacecraft operating in a modified flight sequence.

b. Description of Test

The Spacecraft was mated to the LMSC flight adapter in the test pit area of Building 179. The Agena shroud was removed and the external control cables were disconnected. The Spacecraft was operated in a modified flight sequence and it was powered by batteries. The control and monitoring was accomplished by means of an r-f link. The TV Subsystem was tested in warmup and full-power modes of operation.

c. Test Data Evaluation

The performance of TV Subsystem was normal. The review of strip chart recording indicated slight variations of r-f power profile. The variation was attributed to the presence of JPL representative in the pit area during the test. Also, the last readout of F-Channel Power Amplifier cathode current on 90-point telemetry dropped to 1.05 volts. This was due to the new batteries causing the F-Channel power supply to draw more current.

G. Vibration Tests

1. *X-Axis Vibration Test (JPL Procedure 3R311.05)*

The X-axis vibration test was performed on January 8, 1965, in accordance with JPL Procedure 3R311.05.

a. Purpose of Test

The purpose of the X-axis vibration test was to verify that the TV Subsystem was capable of withstanding X-axis vibrations equivalent to or greater than the vibrations imparted by the Atlas and Agena vehicles during the launch and orbit-injection operations. Since the TV Subsystem was to perform its picture-taking function during the terminal phase of the mission, proper operation after the specified levels of vibration was also required as part of this test.

b. Description of Test

Batteries were installed on the TV Subsystem, and the entire Spacecraft was mounted on a special test fixture designed to simulate the shear and tension ties normally utilized to mate the Spacecraft to the Agena adapter, (ref: JPL Procedure 3R115).

During the vibration, the output of the Spacecraft was monitored by a two-way r-f link. A Stoddard antenna was positioned adjacent to the Spacecraft omni-antenna and interconnected to a directional antenna located on the roof of the Environmental Test Laboratory (ETL) for transmission to the System Test Complex located at the Spacecraft Assembly Facility.

Prior to actual vibration of the Spacecraft, a modal survey in X- and Y-axes was performed in accordance with JPL Procedure 3R117. Furthermore, two runs of X-axis equalization and a noise burst test were performed. During the vibration, the TV Subsystem was operated in the cruise mode of operation, and its operation was monitored by Channel-8 15-point telemetry.

Following the X-axis vibration test, a functional verification test was performed on the TV Subsystem. Prior to the full-power sequence, a white reflective surface was placed within the fields of view of the cameras, and then illuminated. The OSE was connected in hardline mixed-signal configuration for reception of the r-f signals from the TV Subsystem. Because of an oversight during preparation for this test, reduced-power jumpers were not removed from the junction box, and the verification portion of the test was first completed in reduced-power mode of operation. This portion of the test was then repeated with Subsystem operating in the full-power mode, as is specified in JPL procedure; only the results of the second run are reported herein.

c. Test Evaluation

Since the collimators were not employed in this test, a detailed evaluation of the cameras and video output was not possible. Review and analysis of the data obtained during the test indicate that performance of the TV Subsystem did not deteriorate after being subject to vibrations.

2. *Y-Axis Vibration Test (JPL Procedure 3R311.05)*

The Y-axis vibration test was performed on January 9, 1965, in accordance with JPL Procedure 3R311.05.

a. Purpose of Test

The purpose of this test was the same as that of the X-axis vibration test, except that the vibrations were imparted to the Y-axis of the Spacecraft.

b. Description of Test

The test setup and procedure for the Y-axis vibration test was the same as for the X-axis vibration test, except that a modal survey was not required as a prerequisite.

c. Test Evaluation

Review and analysis of the data obtained during the test indicate that the performance of the TV Subsystems did not deteriorate after being subjected to vibration. At the completion of this test, the aspect ratio of all camera reticles was checked and found to be well within the specified limits.

3. *Torsional Vibration Test (JPL Procedure 3R311.05)*

The torsional vibration test was performed on January 11, 1965, in accordance with JPL Procedure 3R311.05.

a. Purpose of Test

The purpose of this test was the same as that of the X-axis vibration test, except that torsional vibrations were imparted about the roll axis (e.i. Z-axis) of the Spacecraft.

b. Description of Test

The test setup and procedure for the torsional vibration test was the same as for the X-axis vibration test, except that modal survey was not required as a prerequisite.

c. Test Evaluation

Review and analysis of the data obtained during the test indicate that the performance of the TV Subsystem did not deteriorate after being subjected to vibration.

4. Z-Axis Vibration Test (JPL Procedure 3R311.05)

The Z-axis vibration test was performed on January 12, 1965 in accordance with JPL Procedure 3R311.05.

a. Purpose of Test

The purpose of this test was the same as that of the X-axis vibration test, except that the vibrations were imparted to the Z-axis of the Spacecraft.

b. Description of Test

The test setup and procedure for the Z-axis vibration test was the same as for the X-axis vibration test, except that the modal survey in X- and Y-axis was performed after the completion of the test.

c. Test Evaluation

Review and analysis of the data obtained during the test indicate that the performance of TV Subsystem did not deteriorate after being subjected to vibration. While some amplitude deviation was observed in the OSE recording of the Low Current Voltage Regulator output transmitted over Channel-8 15-point telemetry, the strip chart data obtained at Central Recorder was normal. Therefore, it was concluded that the deviation noted in the OSE recording was due to ground station or operator adjustments. Furthermore, the modal test, which was performed at the conclusion of Z-axis vibration, showed that no structural changes of the TV Subsystem occurred during the vibration tests.

H. Post-Vibration Test

1. *Post-Vibration System Test No. 4 (JPL Procedure 3R300.19)*

The post-vibration system test was performed on January 14, 1965, in accordance with JPL Procedure 3R300.19.

a. Purpose of Test

The purpose of this test was to verify that TV Subsystem operation had not been degraded as a result of the vibration tests.

b. Description of Test

During this test, the Spacecraft configuration was not altered from the setup used for the vibration test sequences, except that collimators were installed on the cameras, and a hardline connection between the 4-port hybrid and OSE was made. An RTC -7 command was used to set the TV Subsystem into warmup mode of operation; the full-power mode was then effected by the outputs of the 80-second timers. The TV Subsystem test was terminated by an RTC-5 command. The test was performed using battery power.

c. Test Evaluation

During this test, the performance of the TV Subsystem was found to be normal. While the strip-chart recording of the r-f power profile showed some variations in the power output, these excursions remained well within the allowable range. Similarly, it was noted that the battery voltage, as measured at the input of High Current Voltage Regulator, was lower than usual, though within the specified limits. The drop in battery voltage was attributed to the inclusion of the Power Control Relay into the battery circuit. Also, during the cruise mode of operation, zero-reference frequency at the output of Channel-8 Voltage Controlled Oscillator was measured and found to be 3031.2 cps.

I. Vacuum-Thermal Tests

1. Pre-Mission Verification Test (JPL Procedure 3R302.09)

The pre-mission verification test was performed on January 19, 1965, in accordance with JPL Procedure 3R302.09.

a. Purpose of Test

The purpose of this test was to verify the integrity of all cable interconnections between the RA-9 Spacecraft and the System Test Complex which controls the Spacecraft. To ensure proper operation of TV Subsystem before subjecting it to the mission tests, an abbreviated electrical test was performed.

b. Description of Test

The Spacecraft Bus and TV Subsystem were mated and then installed in the JPL space simulator. The cables were connected in accordance with JPL Procedure 3R116, and collimators were refocused for use in vacuum and installed on the cameras. This test was performed on external power.

c. Test Evaluation

The resolution of each camera was obtained by observing the collimator-mounted RETMA charts and the results were as follows: for F_a Camera, 750 TV lines; F Camera, 775 TV lines; P1 and P2 Cameras, 175 TV lines; P3 Camera, 280 TV lines; and P4 Camera 315 TV lines. While some shutter-induced noise was evident in all partial-scan cameras, the noise at the output of P2 Camera was particularly pronounced. The performance of TV Subsystem was deemed normal, and it was cleared for mission tests.

2. Mission Test No. 1 (JPL Procedure 3R302.09)

The mission test No. 1 was performed during the period from January 19 through January 22, 1965, in accordance with JPL Procedure 3R302.09.

a. Purpose of Test

The purpose of this test was to verify proper operation of the TV Subsystem in a near-space vacuum and high-temperature (35°C) environment. Furthermore, its purpose was to detect any interactions that may result from operation in a normal flight sequence when the Spacecraft is exposed to a space environment, and to demonstrate its capability to operate for an extended period of time under these conditions, as is required during the mission.

b. Description of Test

The TV Subsystem configuration was the same as in the previous test, and its operation was monitored and controlled by the System Test Complex. The TV Subsystem was powered from batteries. A power control relay was connected between the batteries and the High-Current Voltage Regulator to enable the use of batteries or external power. To observe the occurrence of any discharge in the Transmitter Power Supplies, corona-detection equipment was used to provide a continuous record of battery current. Also, to detect any emi, the Spacecraft was monitored during the test.

A real-time (66-hr) mission was run at pressures of 10^{-5} mm Hg or less, and at a temperature of approximately 35°C. The chamber-wall temperature was reduced to approximately -180°C. The test temperature was obtained by means of strip heaters installed on the solar-illuminated surfaces of the TV Subsystem. At the beginning of the mission, the TV Subsystem was set to cruise mode of operation. During the terminal maneuver, F-Channel was turned on by the Clock and allowed to remain in full power for 14 minutes. An RTC-7 command was used to turn on P-Channel, which was then operated in full-power mode for 10 minutes. The operation of both channels was terminated by means of an RTC-5 command.

c. Test Evaluation

The performance of the cameras was found to be satisfactory, except for F-shutter induced microphonics exhibited by P1 Camera which were quite pronounced. Furthermore, at the beginning of the test, the white levels of P3- and P4-Cameras were found to be too high. This was attributed too high collimator voltage. Consequently all collimator voltages were adjusted to 25.5 volts, which cleared the problem for duration of the test. The performance of communications was good, and examination of the power profile showed a peak output of 64 watts at the onset of the test which gradually decreased to 61.5 watts. While some variations of F-Channel output were noted, they were of short duration and remained within the specified limits. No emi or corona discharge were noted during this test. The performance of the TV Subsystem during this test was considered to be good.

3. *Mission Test No. 2 (JPL Procedure 3R302.09)*

The mission test No. 2 was performed during the period from January 22 through January 25, 1965, in accordance with JPL Procedure 3R302.09.

a. Purpose of Test

The purpose of this test was to verify proper operation of the TV Subsystem in a near-vacuum and low-temperature (11°C) environment. Furthermore, its purpose was to detect any interactions that may result from operation in a normal flight sequence when the Spacecraft is exposed to a space environment, and to demonstrate its capability to operate for an extended period of time under these conditions, as is required during a mission.

b. Description of Test

Since this test was performed immediately after mission test No. 1, the vacuum in the space simulator was preserved, and consequently, the Spacecraft configuration remained the same as for the previous test. The test was started with the TV Subsystem at 35°C and its temperature was allowed to decrease to 11°C where it was stabilized. At the beginning of the mission, TV Subsystem was set to cruise mode of operation. During the terminal maneuver, both F- and P-Channels were turned on by an CC&S TV-2 command. After operating for 10 minutes in full power, the TV Subsystem was turned off by means of an RTC-5 command.

c. Test Evaluation

The performance of the cameras was satisfactory. The microphonics exhibited by P1 Camera during the previous test was not evident in this test. However, P1 Camera output did contain some 10-kc noise. Slight variations of the power profile were also noted. No corona discharge or emi were observed during the test. The overall performance of the TV Subsystem was satisfactory.

J. RF Link Tests

1. Pre-RF Link Verification Test (JPL Procedure 3R320.03)

The pre-RF link verification test comprised the terminal-mode sequence specified in JPL Procedure 3R320.03, and was performed on January 27, 1965.

a. Purpose of Test

The purpose of this test was to verify proper electrical performance of the TV Subsystem before proceeding with r-f link verification test.

b. Description of Test

During this test, the Spacecraft configuration was the same as during the mission tests except for the following changes. The Spacecraft was mounted directly to the space simulator floor, and a copper screen was placed around it. Except for the control cable to the power relay between the Batteries and High-Current Voltage Regulators, all hardware connections were removed. The strip heaters and camera collimators were also removed. The communication with the Spacecraft was accomplished by means of r-f links utilizing probe antennas.

TV Subsystem was turned on into warmup mode by CC&S TV-2 command. After 80 seconds, both F- and P-Channels were automatically set to the full-power mode of operation. Ten minutes later, the TV Subsystem was turned off by an RTC-5 command. The operation of the cameras was checked by placing a light box within their field of view and viewing it on the monitor display. The test was performed on battery power at ambient temperature and pressure.

c. Test Evaluation

The performance of the Cameras was deemed normal. However, some shutter-induced noise was exhibited on the outputs of the P2, P3, and P4 Cameras, and shutter-induced vidicon microphonics were observed on the output of the F_a and P2 Cameras. On one occasion P1 Camera lost synchronization because noise spikes interferred with the operation of the d-c level clamp circuit.

2. RF Link Verification Test (JPL Procedure 3R320.03)

The r-f link verification test was performed on January 27 and January 28, 1965, in accordance with JPL Procedure 3R320.03.

a. Purpose of Test

The purpose of this test was to verify the proper operation of the TV Subsystem in a simulated space environment with a minimum of support equipment connected to the Spacecraft.

b. Description of Test

During this test, the Spacecraft configuration was the same as for the previous test, that is, operated by battery power, and a light box was used to illuminate the cameras. The test was performed in the space simulator at pressures of 10^{-4} mm Hg, or less. The chamber wall temperature was reduced to approximately -180°C, and the test temperature of approximately 22.5°C was obtained by means of solar simulation. The terminal-mode sequence was performed in accordance with JPL Procedure 3R320.03.

c. Test Evaluation

The performance of TV Subsystem was normal. R-f output measurements verified radiation levels in excess of 70 watts. A re-calibration of the r-f link showed a decrease of attenuation in the r-f link by 0.98 db from that obtained during the previous test. This was attributed to the effect of temperature on the cable. Also, during this test, telemetry data indicated a malfunction of the P-Channel Battery temperature sensor (MR2271). Since this Battery (Serial No. 115) was not intended for flight use, no further action was taken.

3. Directional Antenna Deployment Test (JPL Procedure 3R243.01)

The directional antenna deployment test was performed on January 30, 1965, in accordance with JPL Procedure 3R243.01.

a. Purpose of Test

The purpose of this test was to verify the performance of the TV Subsystem during deployment of the directional antenna through its range of flight angles. Specifically, the purpose of the test was to monitor the outputs of the TV Subsystem for any occurrence of rfi due to the articulation of the antenna.

b. Description of Test

During this test, the Spacecraft configuration was the same as for the previous tests, except that the solar panels were installed and extended. The directional antenna drive was powered from an external 400-cycle source, and the antenna was articulated in a continuous motion from 0 to 155 degrees and then back to 0 degrees.

c. Test Evaluation

The overall performance of TV Subsystem was satisfactory. The strip chart recording of transmitter power output showed wide variations. This was considered normal and attributed to the variations of the coupling factor between the antenna and pickup probe. Since the coupling factor varies in accordance with near-field geometrical alterations, it was not possible to obtain accurate measurements of transmitter output.

K. Special Tests

1. TV Subsystem Tilt Test

The TV Subsystem tilt test was performed on February 1, 1965. No formal procedures were followed in performing this test.

a. Purpose of Test

The purpose of this test was to investigate the possibility of camera-shutter failure due to weak detent mechanism by operating the shutters in horizontal and vertical positions, and to determine the correlation, if any, between the shutter-induced noise and the orientation of the shutters.

b. Description of Test

The TV Subsystem was mounted on the Subsystem Test Stand, and the thermal shrouds were removed. All hardline connections were made, except for cable 23W27 which would have interferred with the tilting operation. To evaluate the operation of the cameras, a white card illuminated by flood light was placed within the field of view of each camera. The test comprised four runs, and pertinent details are summarized in Table A-2.

TABLE A-2
TV SUBSYSTEM TILT TEST SEQUENCE

Run	Orientation		Operating Commands	
	Shutters	TV Subsystem	Turn - On	Turn - Off
1	Vertical	Pointing Downwards	CC&S TV-3	RTC-5
2	Horizontal	Horizontal	RTC-7	RTC-5
3	Vertical	Pointing Upwards	CC&S TV-3	RTC-5
4	Vertical	Pointing Downwards	RTC-7	RTC-5

During each run, TV Subsystem was operated in full-power mode for a period of two minutes. The test was performed using external power.

c. Test Evaluation

All camera shutters operated normally during all sequences of the test. During the first sequence, noise spikes were observed at the output of F_a-Camera. Review and analysis of the 35-mm film showed these spikes to be 3-kc coherent raster noise having an amplitude of 50 to 75 millivolts (MR2272). During the second sequence, when the shutters were in a horizontal position, a reduction of shutter-induced noise at the output of partial-scan cameras was noted. Furthermore, telemetry data disclosed a malfunction of camera-bracket temperature sensor No. 3, which was replaced after the test (MR 2273).

2. TV Subsystem Evaluation Test

The TV Subsystem evaluation test was performed on February 8, 1965. No formal procedures were followed in performing this test.

a. Purpose of Test

The purpose of this test was to verify proper operation of TV Subsystem prior to performing the pre-shipment system test. Specifically, the test was performed to verify that the noise observed at the output of F_a-Camera during the previous test does not recur, and to check the operation of the newly installed camera-bracket temperature sensor No. 3.

b. Description of Test

The configuration of the TV Subsystem was same as during the previous test, except that batteries and thermal shrouds were installed. The test comprised two sequences. During the first sequence, the orientation of the Subsystem was the same as for run No. 1 in the previous test, while for the second sequence, the orientation was the same as for run No. 3. The operation for both sequences was the same; an RTC-7 command was used to turn on TV Subsystem, and the sequence was terminated by an RTC-5 command.

c. Test Evaluation

The performance of TV Subsystem was normal, and no noise was evident at the output of the F_a Camera. However, review of telemetry data indicated a malfunction of the unregulated voltage bus. This was later traced to high contact resistance at a pin of a cable connector (MR 2274). After the test, the connector was cleaned and the malfunction was cleared.

L. Pre-Shipment Tests

1. Pre-Shipment System Test (JPL Procedure 3R300.19)

The pre-shipment system test was performed on February 11, 1965, in accordance with JPL Procedure 3R300.19.

a. Purpose of Test

The purpose of this test was to verify proper operation of the Spacecraft after the reassembly and to ensure that the Spacecraft was ready for shipment to ETR.

b. Description of Test

The Spacecraft was mounted vertically on the System Test Stand and was operated by external power. Direct access between the Spacecraft and OSE was provided by cables which carried test stimuli and allowed monitoring of Spacecraft circuits and functions. To enable evaluation of the cameras, collimators were attached. The Spacecraft was then subjected to an accelerated mission simulation at ambient conditions.

c. Test Evaluation

The performance of TV Subsystem was satisfactory. While some 3-kc noise on the output of the F_a-Camera was observed, its operation was within the specified limits. However, in order to locate the source of this noise, a special test was performed prior to the shipment.

2. Special F_a-Camera Test

The special F_a-Camera Test was performed on February 11, 1965. No formal procedures were followed in performing this test.

a. Purpose of Test

The purpose of this test was to investigate the cause of 3-kc noise observed in the output of the F_a Camera.

b. Description of Test

The TV Subsystem was demated from the JPL Bus, was mounted on the test stand. Five abbreviated full-power runs were then performed. During the first run, both F- and P-Channels were turned on, while for the remainder of the test, only F-Channel was in operation.

c. Test Evaluation

During the first run, F_a-Camera performance was similar to that observed in the preceding test. By turning off the P-Channel, the source of the 3kc noise was isolated to the F-Channel, and the remainder of the test was performed with P-Channel turned off. In the course of the last three runs, various components and cables were flexed in order to locate the cause of noise, but no definite conclusions could be reached. Insomuch that the 3-kc noise was not detrimental to F_a-Camera operation, the TV Subsystem was shipped to ETR on February 18, 1965.

a. Purpose of Test

This test was performed to verify that no damage was incurred by the TV Subsystem during shipment from JPL to ETR. Furthermore, the purpose of the test was to evaluate camera shutter durability.

b. Description of Test

The thermal shrouds and top hat were removed and the TV Subsystem was mounted on its test stand. To check the performance of the cameras, a white surface illuminated by flood lights was placed within their fields of view. Prior to the test, grounding screws at the rear of F_a-Camera were loosened and retightened to ensure the presence of a satisfactory ground connection. The test was performed in two parts. During the first part, TV Subsystem was operated at full power and was pointed towards the floor so that the shutters could operate in a vertical position. For the second part the Subsystem was operated in reduced power mode, and was tilted slightly from its vertical position so that the shutters could operate in a horizontal position. The test was performed on external power.

c. Test Evaluation

The TV Subsystem performance was found to be normal, and it showed no deleterious effects due to shipment. The shutters operated in a satisfactory manner and no noise was evident at the output of the F_a Camera.

2. Clock Verification Test

The clock verification test was performed from February 23 through February 26, 1965. No formal procedures were followed in performing this test.

a. Purpose of Test

The purpose of this test was to verify the timing of the TV Subsystem Clock, and to check the operation of F- and P-Channels.

b. Description of Test

The configuration of TV Subsystem was the same as in previous test except that the batteries were installed and the test was performed using internal power. The test sequence is given in Table B-2.

TABLE B-2
CLOCK VERIFICATION TEST SEQUENCE

Date	Time (EST)	Operation Function
2/23/65	21:23:00	Clock Start
2/24/65	05:23:11	8-hour Clock Pulse received
2/24/65	13:23:20	16-hour Clock pulse received
2/24/65	21:23:29	24-hour Clock pulse received
2/25/65	05:23:23	32-hour Clock pulse received
2/25/65	21:23:39	48-hour Clock pulse received
2/26/65	12:53:36 (T + O)	F-Channel turn on effected by Clock command
2/26/65	T + 1'20"	F-Channel in full power
2/26/65	T + 2'	P-Channel warmup effected by RTC-7P command
2/26/65	T + 4'30"	TV Subsystem turned off by RTC-5 command
2/26/65	T + 6'	Verified that Clock pulse was reset and turned the cruise-mode off.

c. Test Evaluation

The on-board clock was checked against the DMS console digital clock, and the timing was found to be in excess of nominal by 36 seconds, but well within the ±5 minutes tolerance. The TV Subsystem operation was normal.

C. Initial System Tests

1. Backup Functions Test (JPL Procedure 3R305.09)

The back-up functions test was performed on March 1, 1965, in accordance with JPL Procedure 3R305.09.

a. Purpose of Test

The purpose of this test was to verify proper operation of the back-up command functions which cannot be conveniently checked during regular systems tests.

b. Description of Test

The TV Subsystem was mated with the Spacecraft Bus for this test, and top hat and thermal shrouds were installed. The Subsystem was powered from an external power source. Collimators were mounted on the cameras, and all camera outputs were recorded on 35-mm film. R-f output was through hardline connections between the omni-directional antenna and the OSE. The back-up commands tested are listed in Table B-3.

TABLE B-3
COMMANDS TESTED DURING BACK-UP FUNCTIONS TEST

Command	Function
Agena Separate Microswitch	Starts the 64-1/2 hour count of the Clock.
Hydraulic Timer Command	Provides a ground enable for the SCR gate current-limiting resistors. Activates Cruise Mode.
Solar Panel RV Arming Microswitch	Switch activation provides a ground enable for the SCR gate current-limiting resistors. Activates Cruise Mode. (This command is in parallel with the Hydraulic Timer Command)
CC&S TV2 Command	Places F- and P-Channels into warmup. (This command is in parallel with and is a back-up command for RTC-7.)
Cruise ON Test Command	Removes power from the Clock. (This command is from the GSE.)

During the test, two full-power mode runs were performed; the first full-power run, which lasted 1 minute and 40 seconds, was followed by 2 minutes of cruise-mode operation, and then the second run was performed for a period of 6 minutes.

c. Test Evaluation

The performance of TV Subsystem was normal. The review of 35-mm film showed that the previously noted 60 cps noise originating in the GSE was completely eliminated.

2. Operational Checkout by RF Link (JPL Procedure 3R315.05)

Testing of the r-f link was performed on March 3, 1965, in accordance with JPL Procecure 3R315.05.

a. Purpose of Test

The purpose of this test was to verify that the TV Subsystem will operate properly when commands to the Spacecraft and data from the Spacecraft are transmitted and received by means of the r-f link (no wires).

b. Description of Test

The Spacecraft was in flight configuration for this test (all GSE and ground cables disconnected). Instead of collimators, a white surface illuminated by flood lamps provided the target for exposure of the cameras. Two terminal modes of operation were performed during this test. TV Subsystem turn-on for the first terminal mode was accomplished by CC&S TV-2 command, while the turn-on for the second was by means of an RTC-7 command. Both sequences were terminated by an RTC-5 command. This test was performed on internal power.

c. Test Evaluation

The TV Subsystem performance was deemed satisfactory, and following this test the pre-flight preparations were carried out.

3. Abbreviated TV Subsystem Test (RTSP 1100A, Appendix R)

The abbreviated TV Subsystem test was performed on March 7, 1965, in accordance with a modified RCA Specification RTSP 1100A, Appendix R.

a. Purpose of Test

The purpose of this test was to verify the proper operation of TV Subsystem prior to system test No. 7.

b. Description of Test

The TV Subsystem was demated from the JPL Bus, and collimators were installed. The Subsystem was set to cruise mode, and F- and P-Channel warm-up was executed simultaneously by RTC-7 command. Subsequently, the full power was turned on by the 80-second timer. After the TV Subsystem was operated in full-power mode for approximately 4 minutes, an RTC-5 command was used to terminate the test. The test was performed using external power.

c. Test Evaluation

During this test, the TV Subsystem performance was normal, except for the P-Channel battery-case temperature readout on 90-point telemetry which was unusually low. The cause for this abnormal reading was traced to a malfunctioning temperature sensor (MR 2313), which was subsequently recalibrated.

4. System Test No. 7 (JPL Procedure 3R300.20 and ETR 3R300.06)

The final system test was performed on March 12, 1965, in accordance with JPL Procedures 3R300.20 and ETR 3R300.06.

a. Purpose of Test

The purpose of this test was to verify TV Subsystem operation when the Spacecraft is subjected to an accelerated mission simulation in ambient environment.

b. Description of Test

The Spacecraft was mounted on the Agena Adapter and direct-access cables were connected between the Spacecraft and OSE to provide test stimuli and to enable the monitoring of Spacecraft circuits and functions. To enable evaluation of the cameras, collimators were attached, and the video outputs of the cameras were recorded on 35-mm film. R-f output was obtained through hardline connections between the omniantenna and OSE. The test sequence, as specified in JPL Procedure 3R300.20, was performed using external power. Procedure ETR 3R300.06 requirements were fulfilled by operating the TV Subsystem in full-power mode for two minutes, deriving operating power from the on-board batteries. The latter sequence provided the last opportunity to check the condition of individual cells in the flight batteries.

c. Test Evaluation

The TV Subsystem performed normally. Flight battery terminal voltages were measured and the results were as follows:

		F-Battery Voltage	P-Battery Voltage
Initial Open Circuit Voltage		40.85	40.84
Cruise Voltage			40.35
Warmup Voltage		35.10	34.9
Full-Power Voltage	Start	33.79	33.69
	End	33.80	33.60
Final Open-Circuit Voltage		40.54	40.47

Following this test, the TV Subsystem was demated from the Spacecraft Bus and was placed on its tilt stand. Collimators were removed, camera lenses were cleaned, and remaining shroud screws were installed and torqued.

D. Explosive-Safe Facility (ESF) Tests

1. ESF Television Full-Power RF Test (JPL Procedure 3R235.06)

The ESF television full-power r-f test was performed on March 12, 1965, in accordance with JPL Procedure 3R235.06.

a. Purpose of Test

The purpose of this test was to check the r-f connection between the TV Subsystem and the Communications Case II in the Spacecraft Bus, and to verify the r-f path from TV Subsystem to the directional antenna. A calibrated probe, with which the r-f power output was monitored, was installed. A copper screen was placed around the Spacecraft. After the Spacecraft was turned on, the TV Subsystem was set to full-power mode of operation. The r-f power output was measured and the operation of the cameras was checked by viewing a white target surface which was illuminated by flood lamps. The test was performed on internal power.

c. Test Evaluation

The TV Subsystem operated normally during the test. Battery terminal voltages were measured and the results were as follows:

System Condition		F-Channel HCVR Input (Volts)	P-Channel HCVR Input (Volts)
TV Subsystem Off		40.45	40.45
Cruise On		40.50	39.45
Full Power Voltage	Start	33.49	33.50
	End	32.79	32.84

2. ESF Reduced-Power Operational Checkout (JPL Procedure 3R317.06)

The ESF reduced power operational checkout was performed on March 16, 1965, in accordance with JPL Procedure 3R317.06.

a. Purpose of Test

The purpose of this test was to verify that the Spacecraft was ready for launch-pad operation. The test provided a crosscheck of TV Subsystem performance and allowed monitoring the susceptibility of the TV Subsystem to electro-magnetic (emi) and radio-frequency (rfi) interference.

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b. Description of Test

The Spacecraft was in flight configuration, and the Agena shroud was installed. The Spacecraft was mounted on the transporter and powered by the flight batteries. To permit the evaluation of cameras, the shroud lights were checked and installed. The TV Subsystem was commanded through a terminal-mode operation by means of RTC-7 reduced-power command.

c. Test Evaluation

The operation of the TV Subsystem during this test was normal. The r-f input level to the OSE for this test was approximately-62 dbm which was somewhat lower than preferred, but within the receiver threshold region. When beacon signal was radiating from the directional antenna, noise level of the video signal was measured to be about 50 to 70 millivolts. No significant noise null was observed during the transfer of the beacon signal from the directional to omidirectional antenna. Although, no appreciable change of noise amplitude was apparent on any camera video signal after switchover, the characteristic noise on the P-Cameras became coarser.

Twice during the test, P1 Camera lost synchronization as result of noise interfering with the operation of the d-c clamp circuit. The interference occurred when the noise level was clamped back to the black level which lowered the entire video of the associated horizontal lines below black level. This type of disturbance had been observed on previous occasions, but was not expected to constitute a mission problem where shutter-induced noise was anticipated to be minimal.

E. Final Launch Pad Tests

1. Pre-Countdown Test (JPL Procedure 3R304.08)

The pre-countdown test was performed on March 17, 1965, in accordance with JPL Procedure 3R304.08.

a. Purpose of Test

The purpose of this test was to verify the compatibility of Blockhouse Launch Complex Equipment with the OSE and the Spacecraft. The test also served to verify all Spacecraft electrical interfaces and to ensure that all subsystems were in the ready condition.

b. Description of Test

The Spacecraft was mated to the Atlas-Agena launch vehicle which was in place on the launch pad at ETR Complex 12. During the cruise mode of operation, the TV Subsystem was tested to verify that an RTC-7 command would not effect turn-on of the TV Subsystem while the "ground bus enable function" was reset. The Subsystem was then operated in reduced-power mode, and monitoring of the shroud lights served as a check that the TV Subsystem was functioning. The test was performed using flight batteries.

c. Test Evaluation

The performance of the cameras was normal, and no noise was evident on either the P- or F-Channel video signal. After the beacon signal was switched over the directional antenna, rfi noise was observed on the outputs of the F_b and P4 Cameras. The noise was measured to be 90 millivolts and 40 millivolts for the F_b and P4 Cameras, respectively. At the end of the test, the initiation of the RTC-5 command was slightly premature with the result that the 90-point commutator stopped on telemetry point 90-59, (P Battery terminal voltage). Since this point is common to telemetry point 15-6 on the 15-point commutator, the effects on point 15-6 were taken into consideration at the beginning of the next test.

2. Simulated Countdown (JPL Procedure 3R309.09)

The countdown was performed on March 19, 1965, in accordance with JPL Procedure 3R309.09.

a. Purpose of Test

The purpose of this test was to simulate the launch countdown and to verify that all Spacecraft subsystems were operating properly. Its secondary purpose was to familiarize test personnel with countdown procedures.

b. Description of Test

The configuration of the Spacecraft during this test was the same as for pre-countdown test, and the procedure that was followed in checking out the TV Subsystem was the same as that used for the proceeding test.

c. Test Evaluation

The performance of the TV Subsystem was similar to that observed during the previous test, and the Subsystem was deemed ready for launch. While a drop of about 0.7 db in the r-f output was noted during this test, this was attributed to the change in coupling in the r-f link to the blockhouse instrumentation.

3. Launch Countdown (JPL Procedure 3R309.09)

The launch countdown was performed on March 21, 1965, in accordance with JPL Procedure 3R309.09.

a. Purpose of Test

The purpose of this test was to confirm that all the Spacecraft subsystems were operative. Following this test the actual launch occurs.

b. Description of Test

The configuration of the Spacecraft during this test was the same as for the simulated countdown, and the procedure that was followed in checking out the TV Subsystem was the same as that used in the preceeding test.

TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-9 TV SUBSYSTEMS

MR Number and Date	Subassembly and Serial Number	Component Part	Failure Mode	Test Environment	Cause of Failure	Analysis and Corrective Action
2263 12/14/64	F_a-Camera Assembly, Serial No. 044, Flight Model III-4	N/A	Reduced Level Video	Ambient (JPL)	Design	When F-Channel went into full power, the first frame of F_a Camera video displayed the RETMA pattern at a reduced level (appeared to be a residual image only). This problem with the first F_a-Camera readout after full-power turn-on appears to be an unexposed frame. Transients generated by the operation of the full-power relays in the GSE can reset the steering flip-flop in the shutter drive circuitry of the Camera Electronics Assembly. Thus, the shutter drive is out of synchronization with the shutter position, and one frame of video is lost before synchronization is re-established. No other frames of F_a-Camera video have been lost except at the instant of full-power turn on.
2264 12/17/64	Voltage-Controlled Oscillator, Serial No. 002, Flight Model III-4	N/A	High Output Level	Ambient	Accident	During testing of Flight Model III-4 at JPL, the output of F-Channel VCO, Serial No. 002, was 3 db higher than nominal. This unit, manufactured by Datatronics, had replaced VCO, Serial No. 1034, manufactured by Vector, on this Flight Model. Specification requires that the output of the VCO is to be adjusted for 1.5 volts, peak-to-peak, measured across a 10-kohm load at the end of flight-length subminiature cable. Resistor R5 in the modulator circuit must be adjusted to provide the proper telemetry deviation for a 1.5-volt input to the IF modulator. The encountered problem occurred because the Vector VCO is not an emitter-follower output-type (output impedance is 20 kohms) as the Datatronics unit, and is affected by modulator input impedance which varies from unit to unit. Therefore, the Datatronics VCO is not a direct replacement for the Vector unit without adjustment. Resistor R5 in the modulator has been adjusted so that the telemetry sidebands are 0 db below peak carrier amplitude.
2265 12/17/64	Monitor and Control Panel, GSE, Serial No. 004	N/A	Noise Bursts	Ambient	Design	During System Test No. 3 on Flight Model III-4, the black-field presentation of the full-scan cameras exhibited high-frequency noise bursts at a level of approximately 100 mv, peak-to-peak on the GSE monitor scope. However, there was no evidence of the noise on the 35-mm film. The high-frequency noise bursts were attributed to switching transients within the GSE Monitor and Control Cabinet; these transients have been present in all systems and are caused by the rapid rise time and relatively high amplitude of the black-field signals. With normal intensity on the monitor scope, such noise bursts are not noticeable. Since the noise is not present on the 35-mm film, no further action is contemplated.
2271 1/27/65	Battery, Serial No. 115, Flight Model III-4	Thermistor T85	High Impedance	Ambient (JPL)	Nonassignable	The P-Channel Battery, Serial No.115, that was mounted in the TV Subsystem for the RF Link Test and Antenna Deploy Test was found to have a thermistor that indicated an excessively high impedance. Since this battery is not a flight unit, the thermistor will not be changed. A check of all batteries after Serial No. 100 indicated that all the thermistor values were within tolerance, except for thermistor T2 of Battery, Serial No. 106 (MR4654), whose thermistor has been replaced.

TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-9 TV SUBSYSTEMS (Continued)

MR Number and Date	Subassembly and Serial Number	Component Part	Failure Mode	Test Environment	Cause of Failure	Analysis and Corrective Action
2271 (Cont'd)						Thermistors are checked 100 percent by the manufacturer. The thermistors are placed in a nonconductive temperature bath at 25°C. The bath is controlled in 0.02°C by using a platinum resistance thermometer in conjunction with a Mueller bridge. A negligible amount of power is applied for the resistance measurement, which is made by a wheatstone bridge and an electronic null indicator. The resistance of the thermistor is 42 k ohms 11 percent at 25°C.
2272 2/1/65	F_a-Camera and Electronics Assembly, Serial No. 044/044, Flight Model III-4		Noise Spikes	Ambient (JPL)	Nonassignable	During a special TV Subsystem test in which the Subsystem was oriented at three different angles, noise spikes were exhibited on the output of the F_a Camera. These noise spikes were at a frequency of approximately 3 kc and were 50 to 75 mv in amplitude as viewed on the scope. The problem was viewed only in the first of a series of four tests. The Subsystem was not in a flight configuration for these tests as the thermal shields were not installed. Two additional tests were performed with the Subsystem in the same configuration; however, there was no further occurrence of the problem. When the noise was observed, the Mariner Program Test Complex had been in operation. The interference observed was not coherent on a line-to-line basis and was determined to be approximately 3 kc at 50 mv. Two special tests were performed in an attempt to simulate and isolate the interference, with the Subsystem in the same non-flight configuration. The problem was not observed during these tests. The Mariner Test Complex was not in operation during the subsequent tests. A check of the Mariner Test Complex for the presence of an interference source failed to locate the source of the interference.
MR2273 2/2/65	Temperature Sensor Flight Model III-4	Resistor R7	Low Telemetry Indication	Ambient	Random	In a special Subsystem check, telemetry point 90-86, camera bracket temperature sensor No. 3, indicated 6 instead of 2.7 volts. This reading was traced to resistor R7 in the temperature sensor and the resistor was replaced. After extensive testing at JPL, the defective resistor was X-rayed, checked electrically, and found to be open.
2274 2/8/65	Cable Harness Connector, Flight Model III-4		Telemetry Reading Out of Specification	Ambient (JPL)	Random	During a special test of the TV Subsystem, the output of the P-Channel unregulated bus telemetry point (data point 90-46) dropped from the normal 3.8 volts to approximately zero volt. Investigation disclosed that the failure was caused by a considerable increase in the pin resistance in the cable harness connector to the DCU. Since the current carried by the pin in question is only a few microamperes, the connection can be classified as a dry circuit. Operating under this condition for an extended period of time, it is not unusual for the resistance of the connection to increase considerably. When the connector was wiped by mating and demating, the condition was cleared. Since this circuit is a telemetry reading and is semi-redundant (unregulated bus voltage can be detected by at least two other telemetry points), no further action other than cleaning is recommended at this time. The connectors were inspected, cleaned, and remated. A pin retention test was performed and all pins were satisfactory.

TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-9 TV SUBSYSTEMS (Continued)

MR Number and Date	Subassembly and Serial Number	Component Part	Failure Mode	Test Environment	Cause of Failure	Analysis and Corrective Action
MR2313 3/7/65	Battery Serial No. 107 Flight Model III-4	---	Low Telemetry Indication	Ambient (ETR)	Workmanship	Telemetry point 90-45, P Battery external temperature, indicated 2.15 instead of 2.6 volts during a special Subsystem test. A review of the test data revealed that the resistance of this thermistor has been high, thereby giving a faulty telemetry reading. This battery has an excellent performance record. The 90-45 point is read only during terminal mode and is redundant. A new calibration curve, which reflected the resistance of the thermistor, was prepared.